CERAMICS

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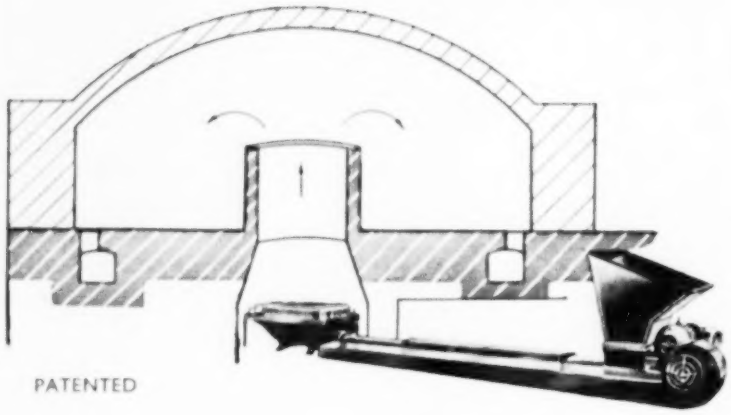

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Ceramics

VOL. II AUGUST, 1950 NO. 18

Practical Instruction in Ceramic Technology

FROM time to time we have pointed out the disadvantages of formal scientific and technical courses as instituted at the universities.

The Ceramic Industries are remarkably free from this didactic and pedantic approach. The well-known Ceramics Department of the North Staffordshire Technical College opens its classes on the "Manufacture of Pottery, Building Materials, Refractories and Vitreous Enamels," on 25th September. These courses indeed are remarkably free from theoretical instruction, divorced from practice. Indeed they serve as a working model for those enlightened educationalists who realise the inadequacies of the present formal university approach.

In London, the Northampton Polytechnic has an enlightened Head of the Applied Chemistry Department, for Dr. Garside is constantly seeking the practical as an adjunct to his theoretical training. Here the winter session begins on the 5th October with visiting lecturers and works visits supplementing a course on Clay Technology.

Next comes the Imperial College of Science and Technology sponsoring a course of lectures from 25th to 29th September in the Royal School of Mines, Prince Consort Road, S.W.7, on "The Firing of Bricks"—the lectures begin at 10 a.m. each day.

Courses of instruction such as those mentioned above come as a hopeful sign that the importance of relating technical training to practice—long overlooked by the science faculties of our universities—is at last being realised.

Strangely enough the impetus comes not from the Universities but from technical institutions whilst it is the former who spend the greatest amount of hard cash subscribed and earned by "sordid commerce."

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Education for Snobbery

• *by Argus* •

I WILL not define "education." There are 30 million adult Britons each with a different conception. That of London Suburbia differs from Merthyr Tydfil, Clydeside or Stoke. And who has the audacity to claim that his interpretation is right?

Yet we need schools of some sort for the young, and we need teachers.

Begin at the beginning! What is the ultimate job for Britain's children? For the vast majority it is industry. Folks must work with their hands on some material to produce a saleable article. On that depends our livelihood, for only with the fruits of that earning can we have the Welfare State, the Arts Council and the longhaired boys at Alexandra Palace.

Surely commonsense says that industry must have on option on a high proportion of the best brains of the community for if we starve industry, we cut the veins of an industrial nation.

No Contact With Industry

But here comes the rub! Most of our teachers—the vast majority in fact—left school, went to the Training College or University—and returned to one or the other to teach. Seldom do they attempt to contact industry or commerce directly.

The child in his impressionable age is awed by his masters. I know these masters—I've taught with them! To school leavers at 15 or 16, the careers master recommends a white collar job and seldom a job at the factory bench.

This has been going on for a generation. Because of the insecurity of the pre-war heavy industries, fathers encouraged their sons towards the professions or clerical jobs. It was most noticeable in the depressed mining areas. Now we complain of a shortage of miners in the 23/35 age group! Any extension of our present educational system will exaggerate this tendency. We will be peopled with planners and no doers!

It's even worse than that!

There is the snob value entering into it. We have State Primary and Secondary Schools catering for the majority. Then there are the greater, and many score of lesser Public Schools. There are Technical Schools and Colleges, the older and the provincial universities (Yes! London is a Provincial in the Don's language). There are decrepit Grammar Schools, and private schools over the baker's shop. There are Academies and Schools for young ladies. Convents and Board Schools.

Each has its snob value! Generally speaking the narrower the scope the bonnier the blazer and cap, and the higher the snob value. It's a good guide!

Social Status

For guidance I've rated them in order of decreasing social status:

Age: 5-12	12-18	Above 18
Preparatory	Public	Oxford and Cambridge
Private	Grammar (old style)	The Rest can fight it out
Elementary	Secondary Technical	Technical Colleges and Polytechnics

Those who attend the type of school higher on the list can look down upon the ones below. Even though both may take the same examination, yet the building endows upon its entrants an eradicable caste stamp!

Now generally the upper middle classes and above emerge from the schools at the top of the list. The lower middle class and workers come from those lower in the list.

Inversely the lower down the list, the more time is devoted to mathematics and science and the higher one looks on my list the more is the attention to Classics.

Pure Science

Birmingham is an industrial centre. I taught in a school there once, where there were 500 to 600 boys and about thirty masters. Out of that only five taught technical subjects and of these only one had experience of industry—their science was very pure! There were a dozen historians and as many linguists. Latin was hammered in with a mallet.

Which reminds me—there is a tragic decline in Latin tags in letters to *The Times*! I think the little book of tags must be out of print!

We hear the Social Reformers bleating for more and more schools. More and more advanced education. Still no doubt it will be advantageous if surburban milkmen, dustmen, chimney sweeps and canvassers can talk exponential mathematics and Emmerson to the lord and master of the semi-detatched villa with all mod. con!

But when we all talk B.B.C., and the Arts Council and Ministry of Culture have done their job, you won't know Mrs. 'Awks the char from her mistress! "Dammit sir! It's the chars who have television sets and washing machines! And that nice young man Cyril working in the bank has been forced to send his boy to the same school as his wife's char!"

There is more rot talked about education than there is about the "form" of racehorses.

A Suggested System

Let's all go to the same school! They do in Switzerland and Sweden. It doesn't matter much about where this education takes place as long as it offers a hygienic background and the child is taught to suspect everything his teacher tells him!

Right! From 5 to 15 we all go to the same school. If we can arrange it for 2 years in this period the child from the town goes to the country and vice versa. Children are naturally great levellers. I knew the first scholarship boy in Dartford Grammar School. The masters called him "Charity Bill," but by scoring forty odd, taking five wickets and thus helping to beat the school rivals, he won the popular boy's prize.

And what a prize! Two volumes of Macaulay's "History of England." What a prize for a 15-year old. How much better a cricket bat, or if the Nobel Prize is cash—why not a cash prize to the schoolboy? It's most surprising how interested small boys are in shillings and half-crowns. Of course the bat and the cash would have gone long ago and by getting books they now grace his bookshelf—unread after 50 years.

We have settled the first part. An Order in Council classifies all schools covering the age group 5-15. Bad for the old school tie business and the makers of that famous school uniform which is a cross between that of a waiter and a dance band leader. This is general education, the 3 R's, a bit of Arts and Crafts and the usual rigmarole.

Tempted Towards Industry

At fifteen comes the break. The best boys will be tempted towards industry unless they show distinct leanings towards classics, language and the Arts.

We are an industrial nation so that some time between 15 and 21 at least 2 years is to be spent part time in a factory. Rembrants and Chopins break up from the gutter, so we won't lose any such genius.

The universities abandon all scientific and technical education. Their technical departments will be classified as Technical High Schools. Their syllabus will be drawn up in collaboration with the various professional institutes of Fuel, Engineering, Chemistry, Physics and so on.

From 15 to 21 the boy will work part time theory and part time as an indentured apprentice in an approved factory. He will be paid at the Union rate. There will be breaks at 17 and 19. Each stage will have an appropriate standard and those wo do not pass high enough will depart for full time employment with appropriate certificates. At 21 he gets a degree of equivalent commercial and social value as that of the university. Those who are outstanding pass on to travelling scholarships for 2 years or more abroad.

Objectives for Education

Our educational system must do two things. Firstly it must inculcate the idea of the importance of industry to Britain and it must ensure that the

next generation cannot have Prime Ministers and Cabinet Ministers who have never seen the inside of a factory workshop as a doer.

Secondly it must encourage more doers and select the planners from the experienced doers. Degrees in Economics unrelated to industrial practice would go. The London School of Economics would become a post-graduate University of Commerce for Administrative Training of the Doers.

I know my critics will howl at me! Prestige, materialism and so on.

But in answer I say that our present educational system supplies theoretical scientists by the score—and no good foremen, chargehands and assistant works managers. The present system of education has sapped high quality potential doers and made them clerks, administrators, Council officials, Civil Servants, teachers and the like, in an industrial community without them having any experience of industry.

Would the Medical Officer of Health suffer from a year in the Scavenging Department? Would a clergyman in a mining community be less useful if he had spent a year in the pits? Would the Head of an Agricultural College be worse off for a year as a farm labourer?

Our educational system is phoney and snob-ridden and until that is ironed out, petty snob values will cloud every issue in the fields of politics, religion, welfare and economics.

TECHNOLOGICAL EDUCATION FOR THE HEAVY CLAY INDUSTRY

A COURSE of lectures and demonstrations in clay technology organised for technologists in the heavy clay industries will be offered at the Northampton Polytechnic, St. John Street, London, E.C.1, next session on Thursday afternoons, from 3.0—5.30 p.m., commencing on 5th October, 1950. This course, which is planned to extend over two terms, that is until Easter, 1951, is organised as the first year of what ultimately is planned to be a two-year course. In addition to the teaching staff of the Polytechnic, a number of specialist lecturers will be assisting with the lectures and demonstrations, and it is hoped that the heavy clay industries in the London and South-East England areas will support this new venture.

Opportunities for Discussion

It should be noted that there will be ample opportunities for questions and discussion after each lecture; and with the object of supplementing lectures a number of works visits are in process of being organised.

Intending students should write to Dr. J. E. Garside, Head of the Department of Applied Chemistry, Northampton Polytechnic, St. John Street, London, E.C.1, for an application form, which should be completed and returned *not later than* 31*st August*, 1950. It is to be emphasised that the number of students who can be enrolled is strictly limited. The fee for the course will be in accordance with the London County Council scheme, which varies according to individual circumstances from free entry for certain students below a specific age limit to £1 per session.

The chief topics to be covered in this course are as follows:

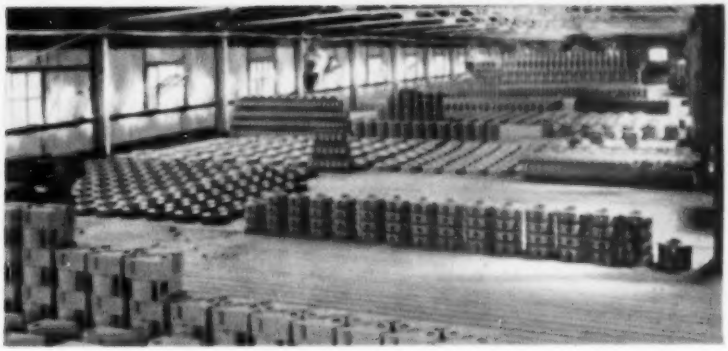
Drying

Principles involved in and the basic requirements of a dryer. Terms used in drying. The mechanism of drying. Instrumentation. Classification and description of typical dryers. Methods of heating dryers and practical problems associated therewith. The efficiency of a dryer.

Firing

The action of heat on clays. Fuels and combustion. Kiln design and construction. Heat transfer and gas flow. Instrumentation. Firing schedules and kiln circuits. Relationship between raw materials, firing treatment and finished properties. The evaluation of kiln efficiency.

Colchester.—The history of Colchester is still very deeply sunk in Roman history. As a reminder of this fact we have received a brochure from Davey Paxman which covers Colchester in past history and in present history. This brochure illustrates the many activities of the Davey Paxman firm from boilers to Diesel engines, land and marine, and the many other activities of the Davey Paxman firm. Those interested in this sort of high-class plant should write to Davey, Paxman and Co. Ltd., Colchester, and ask for Publication No. 1245.



Drying floor, showing variety of refractories made

Refractories for the Steel Industry

A Visit to the Works of Thos. Marshall & Co. (Loxley) Ltd.

By our
INDUSTRIAL CORRESPONDENT

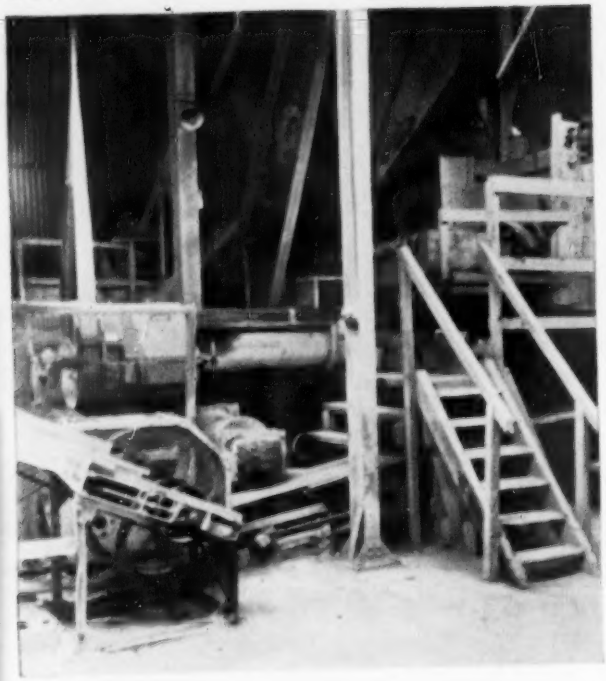
ON a fine summer day there are few pleasanter valleys than that in which is located the Storrs Bridge works of Thos. Marshall and Co. Ltd. The stone walls of the farms sweep down from the adjoining moors, and here and there a grey stone farm merges with the landscape. A narrow winding lane flanked with horse chestnut trees laden with pink blossom leads down to a trout stream, spanned by a stone bridge leading to the works This is a pleasant spot on which to linger on a fine day.

Refractories Made for over 100 Years

In this peaceful setting fireclay products have been made for over a 100 years. Although no continuous records exist in the company's possession now, it is pretty clear that in the early days of the Sheffield crucible steel trade, clay was being mined at Storrs Bridge for crucible pot making. Later in the firm's history firebricks were made on a small scale, firing being done in two updraught kilns. Production of these articles continued for many years with modest improvements from time to time, and for a brief period, when the Sheffield Corporation reservoirs were built farther up the valley, red bricks were made. The type of output changed little till 1916. One or two more kilns had been added, but then with the armament programme demanded by World War I the manufacture of casting pit refractories was introduced. The products were made after the war until about 1920 when falling trade caused output to be diverted to the manufacture of firebacks and parts of domestic fireplaces, all of which were needed for the housing programme. This side of the firm's activities is still maintained.

Expanding Output of Casting Pit Refractories

From 1930 onwards rapid and continuous progress has been made in expanding the output of casting pit



Section of clay preparation plant

refractories, which are the firm's main preoccupation at the present time. To meet this expanding business various kinds of specialised machinery, much of it built to the firm's own designs, and two tunnel kilns for firing have been installed. The first was completed in 1929 and the other a year later. Both have been in operation ever since.

The extent of the expansion in the firm's business may be judged from the output figures, which have risen between the two wars from 50 to approximately 250 ton per week. The latter figure has new been well exceeded, and a branch works has recently been started at Abenbury near Wrexham. This works will use the very fine fire clay mined by the Ffrith Fireclay Co. Ltd.—a subsidiary company.

Technical Department

In 1941 a small Technical Department was set up to control production and to carry out experimental work. This has grown, and has played its part in the company's reputation for reliability and quality of their products. It has also played a big part in the extension of the firm's activities to the manufacture of other refractory products marketed by the subsidiary companies, such as high temperature insulation and carbon refractories.

The company prides itself that most of its 250 employees have been trained from boyhood with the firm. Their skill makes it possible to accept orders for specialised shapes, which have to be hand made.

Works Layout

The works itself stands on a piece of fairly level ground in the bottom of the valley. The fire clay is mined from underground workings in the side of the hill. Use has been made of the natural slope to construct a series of storage bins which are fed by tipping from lorries on a road higher up the hill. It is planned eventually to complete this road so that a one way system of traffic can be introduced. This will undoubtedly ease the traffic problem on the narrow approaches to the factory. The bins hold coke, coal, bricks for grog, fire clay, etc. They are uncovered, and

provide means for weathering the clay. Eventually it is planned to bring the fire clay out of the working at a higher level, so that it can be dumped into an appropriate bin on the hillside. The materials from the bins will then be moved by Chaseside excavator trucks to the grinding pans. The fire clay is ground in the usual type of pan and elevated to screens which deliver it to storage hoppers. Grog is treated similarly. From the storage bins the materials are fed into a mixing trough by means of rotating plates with adjustable scrapers. The amount delivered is checked daily by the laboratory to maintain consistent mixing. This is important. Similarly the water added to the mixing trough is controlled and checked frequently. Before extrusion the material is de-aired. The increase in strength of the green clay product which results from this operation is remarkable.

New Methods of De-airing Clay

Not content to adopt the standard practices of the trade the firm have provided facilities for the development of what promises to be a revolutionary method of tempering and mixing clay. This is the invention of Mr. L. Walker of Modern Industrial Appliances, Sheffield. The invention is fully patented in this country and foreign patents are pending.

A few years ago it was found that if clay dust was placed in a tube and evacuated, and then sprayed with water under pressure the water penetrated the clay mass, whereas when the pressure was not reduced a slurry resulted. The present mixer makes use of this discovery. The ground clay is allowed to enter the vacuum chamber from a hopper and there it is sprayed with water in a mist form from atomising sprays. Clay which has been de-aired in this way offers no resistance to being penetrated and coated with moisture. In this way a de-aired clay is produced with a great saving of mechanical power and labour over the traditional methods, where the clay has to be tempered and then shredded, de-aired and extruded. The clay dust is fed through a rotary pocket valve set to deliver a given weight and the water added is checked with a flow meter. The de-aired clay ware is in every way equal to that produced by other methods and by the use of suitable dies the usual variety of goods can be produced.

The variety of articles made is very

View showing fireback making press

large something like 1,000 different shapes of refractory. In the field of refractories for handling molten metal requirements are:—

(a) resistance to thermal shock from room temperature up to 1,650° C.;
(b) resistance to attack by hot metal and slag at this temperature;
(c) accuracy of shape and size;
(d) accurate jointing of composite assemblies so that metal cannot penetrate;
(e) mechanical strength to avoid breakage in transport.

Marshall's make suitable refractories for direct and bottom or up-hill casting. For the ladle, the company markets lining bricks, standard and non-standard sleeves or rod covers. For some years now a composite sleeve assembly has been made, where basic sleeves made from dolomite are used in those portions of the rod likely to be attacked by lime-bearing ferriginous slags formed in the manufacture of rimming steels, and in other cases where slag attack is severe.

A great variety of stoppers and nozzles is made which are designed to resist the eroding effects of the metal being poured.

Bottom Casting

Bottom casting enables a large number of ingots to be cast at the same time using distribution bricks to divert the metal along several pipes. Some of these shapes can be extruded and then pressed to give accurate fitting between the joints, but the more intricate shapes are hand pressed in metal moulds. The requirements of refractories for bottom casting are:

(a) all parts should joint together to give steel-tight connections;
(b) as little reaction as possible between the metal and refractory;
(c) the brickwork should not be worn or spalled away giving inclusions in the casting;
(d) the parts should fit well into their casings.

The company claim that their refractories meet these conditions and give below the average data for the physical properties. Constant research is going on to improve these properties.

Heat Insulation to Reduce Piping

To reduce piping the head of the ingot mould is lined with a refractory brick which acts as a heat insulator, keeping the metal molten to feed the lower portions of the mould as the ingot freezes. Bricks for this purpose are made in a variety of sizes and shapes. In addition to the properties commonly required in refractories for contact with molten metal insulation is required and the porosity of these bricks is normally 30-35 per cent.

Bricks for tundish linings, ingot mould plugs and furnace lining refractories, including recuperators are also made in many shapes.

As has already been mentioned the firm also make fire clay firebacks. These are made by hand as well as by pressing the plastic clay in a steel mould with a power press.

Drying

The main buildings occupy two floors. The lower one is steam heated and the ware is stood on it for drying. Bricks and smaller shapes are placed on the kiln cars and passed to the dryer which is adjacent to the tunnel kilns. The upper floor is perforated to allow waste heat to rise for drying ware. Recirculation of the air in the work shops with fans hung from the roof has recently been shown to cut the time for drying appreciably. Steam for heating the ground floor is obtained from the steam turbine used to generate most of the electric power used in the factory. The other power requirements are taken from the national grid system.

Firing

Firing is done in two tunnel kilns erected by Gibbons Bros., of Dudley.

	Sleeves	*Nozzles and Stoppers*	*Guide Tubes Runners, etc.*	*Centre Bricks*
Apparent Porosity per cent.	25·0	23·3	21·6	25·5
Bulk Density (grams/c.c.)	1·98	2·02	2·08	1·97
Cold crushing strength (lb./sq. in.)	5,500	8,500	5,200	—
Thermal Shock Resistance (Reversals)	25+	12	5	—

These are about 180 ft. long, the cars being 5 ft. long by 3 ft. 6 in. wide with a setting height of about 3 ft. 0 in. The kilns are fired by coke producers of the suction type to a top temperature of 1,100° C. A rapid firing schedule of 55 hr. from car in to car out is given to the ware.

The output of the tunnel kilns is 80 and 75 ton per week, and in addition there are five intermittent kilns drawn each week giving outputs of between 30 and 80 tons of ware each. Firing in both intermittent and tunnel kilns is controlled by recording pyrometers, and, in addition firing in the intermittent ovens is further controlled by optical pyrometer readings taken frequently in ten or more positions on each kiln. There is sufficient truck space alongside the tunnel kilns to build up a store of green ware for the kiln men to push through at weekends.

A kiln setting of insulation bricks

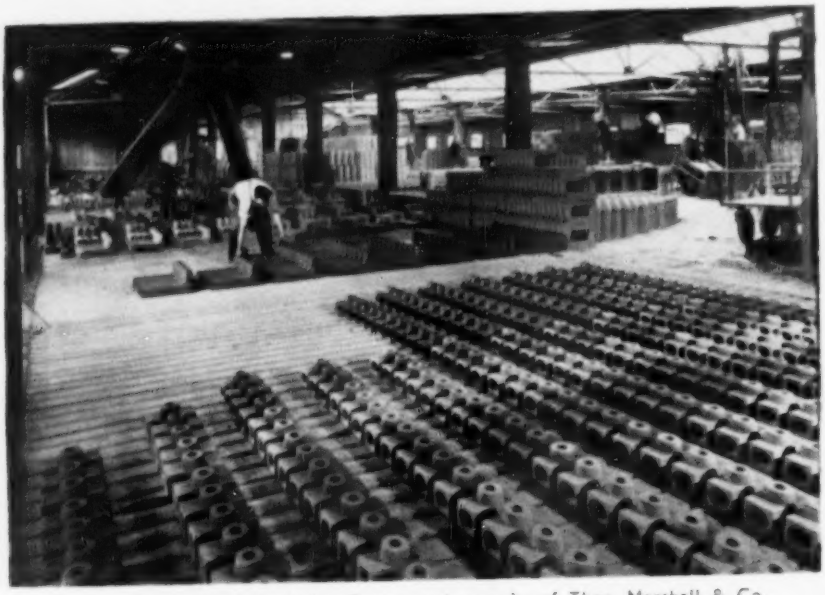
Insulating Bricks

Thermal insulating bricks are marketed by the company's subsidiary firm Kingscliffe Insulating Products Ltd., with works at Loxley, Sheffield, Kingscliffe, Northants, and Wrexham. Two types of insulating brick, the K.I.P. Alumina and K.I.P. Hyper bricks are made and there is also a range of insulating bricks made with a vermiculite base. It is typical of the enterprise of Thos. Marshall Ltd., that they are the first in the field in this country with vermiculite bricks. The K.I.P. alumina brick is a sturdy grade of hot face insulating brick for service at temperatures of 1,250°-1,300° C. It could replace ordinary firebrick in many installations with notable saving in fuel. It is produced from a clay containing 36 per cent. of alumina, has a porosity of 70 per cent. and weighs only one-third as much as the standard grade of firebrick. The cold crushing strength is 270 lb./sq. in., which is reasonably high for this type of brick. Spalling resistance is good and the brick is recommended for lining furnaces and also gas mains, etc.

Hyper bricks are made in standard sizes only and a brick weighs only 2 lb. It is a more efficient insulator than the alumina brick and has a very low heat capacity. The maximum temperature in service recommended is 1,200° C. It is suitable for lining furnace covers where weight is a consideration.

The mineral vermiculite has the

property of swelling when correctly heated to form lightweight granules which are an effective insulator. It can be used as a loose filling, as aggregate in an insulating concrete or bonded and fired to form an insulating brick. Three types of vermiculite brick are made, the maximum temperature in service being 1,100° C. Their properties are not quite as good as the K.I.P. Hyper grade brick, but they can be made economically in shapes and sizes that would be impossible in the alumina and hyper grades. The vermiculite bricks find similar applications to the other grades of insulating bricks already described.



A further view of the drying floors at the works of Thos. Marshall & Co.

Carbon Refractories

Last, but by no means least, it remains to tell the story of work of the associated company, Carblox Ltd., which was formed to work with the Morgan Crucible Co. Ltd., to handle the carbon refractories evolved at Loxley in connection with experiments which led to the building of the first all carbon blast furnace to operate in this country at the Appleby-Frodingham Steel Co.'s works. The story has been told in detail by Mr. G. D. Elliot in a lecture given to a joint meeting of the Blast Furnace and Coke Oven Associations of the Eastern States and Chicago District in Detroit in October, 1949 and reprinted by Carblox Ltd. The Appleby-Frodingham Steel Co., went to carbon refractories in the first place because of a large number of "breakouts." Between 1929 and 1943 in ten furnaces there were twenty-three hearth breakouts. There have been none since the introduction of carbon. Since starting to use carbon the company has installed ten carbon hearths, four carbon boshes, one part carbon stack and two all-carbon furnaces. Carbon is from many angles an ideal refractory, its main limitation is that it cannot be used at temperatures above 350° C. in oxidising atmospheres. Under reducing conditions its properties are superior to those of other refractories.

Properties of Carbon Refractories

Briefly these may be summarised as follows:

Refractoriness—over 3,000° C.—it shows no deformation at 1,470° C. under a load of 2 ton/sq. in.

Volume Stability—relatively stable

NORTH STAFFORDSHIRE TECHNICAL COLLEGE
STOKE-ON-TRENT

CERAMICS DEPARTMENT

PRINCIPAL: H. W. Webb, O.B.E., D.SC., F.R.I.C., M.I.CHEM.E.
HEAD OF DEPARTMENT: W. L. German, M.SC., PH.D., F.R.I.C.

Courses in the Manufacture of Pottery, Building Materials, Refractories and Vitreous Enamels

SESSION 1950-51

Classes commence Monday, September 25th, 1950
Interviewing week: September 11th-15th inclusive

FULL and PART-TIME DAY and EVENING CLASSES are provided in the above subjects.

The FULL-TIME DAY COURSE is of three years' duration (consisting of six months' full-time attendance at the College and six months on a factory in each year) leading to the College CLAYWORKS MANAGER'S CERTIFICATE and the POTTERY MANAGER'S CERTIFICATE, which are recognised both at home and overseas, and also the DIPLOMA IN CERAMICS. The subjects include Theoretical and Practical CERAMICS FUELS, CLAY ENGINEERING, POWER UTILISATION, CHEMISTRY and PHYSICS, and MANAGEMENT SUBJECTS. Specialisation in either Pottery, Refractories, or Building Materials is provided for.

A similar full-time course is also available in VITREOUS ENAMELLING, and includes METALLURGY.

Facilities are available for RESEARCH WORK on problems related to the Ceramic Industries.

Part-time Day and Evening Classes are also available to enable students employed in industry to qualify after a longer period of study.

Special Courses are available in KILNS and FIRING, WORKS MANAGEMENT, COSTING and SALESMANSHIP.

Details of times, fees, etc., can be obtained from the Principal.

—after contraction is approximately 1 per cent. at 1,500° C.

Thermal Expansion—is linear and approximately 0·65 per cent. from 20° C. to 1,000° C.

Thermal Conductivity—high and at least three times that of firebrick.

Mechanical Strength — Carblox bricks commonly give 12,000-14,000 with an average of 10,000 lb./sq. in. under test.

Resistance to Abrasion—is high.

Resistance to Spalling—is high.

Corrosion Resistance—is high to metals and slag as carbon is not attacked or pitted by either.

Specific Gravity—1·92.

Apparent Porosity — (Carblox) Bricks 20 per cent., large blocks approximately 25 per cent.

Bulk Density—grams/c.c. Bricks 1·53, large blocks 1·44.

Permeability—C.G.S. units. Brick 0·015.

Carbon Refractories in Blast Furnaces

Carbon has been used in the form of a paste for carbon ramming since before 1900. It failed as a part hearth lining because of the development of cracks in service. In 1941 the refractories Department of the United Steel Companies began an investigation into the best method of preparing carbon ramming. Subsequently this led to work on the possibility of using preformed carbon refractories for use in blast furnaces of which 1,000 prefired 9 in. squares had been produced at the Loxley works of Thos. Marshall and Co., in February, 1942. Subsequently this company together with the Morgan Crucible Co., formed the Carblox Company. The early bricks were made from coke-tar mixtures. They were used for various purposes including the patching of a breakout in a furnace. Three years later these blocks were found to be completely untouched. Research on carbon refractories has continued ever since, and the company now offer a series of medium sized corrugated fired carbon blocks, which interlock in depth as well as horizontally. This forms a solid structure from which individual blocks cannot work loose and float up through the molten iron. The bricks are laid dry using no jointing cement and no ramming except in small areas at the periphery of the hearth. The depth of the carbon hearth suggested is 5 ft. These blocks come true to shape from the kiln and are not cut or cleaned up in any way.

Reduction of "Blow Outs" and "Scaffolding"

Later experiments showed that the carbon construction, in addition to reducing the incidence of "blowouts" was a cure for "scaffolding" since carbon is not wetted by metals and slags, since the carbon contains no specks of iron compounds, it is not subject to carbon deposition by decomposition of carbon monoxide, which normally causes failures in firebricks used in furnaces. It is also resistant to attack by alkalis and acids.

All Carbon Furnaces

The first all carbon furnace was blown in on 4th April, 1949. Since then it has produced more iron, at a lower use of coke, than it did in the corresponding period of its previous life. This has paid for the extra cost of the carbon.

The effective refractoriness and resistance to abrasion, coupled with higher heat conductivity than that of the normal firebrick means that:

(a) the linings can be thinner—increasing the capacity of the furnace;
(b) life should be increased and less interruption of production for repairs;
(c) cooling of the stack is simplified.

The results of using the first all-carbon furnace have been so encouraging that a second all-carbon furnace has been built incorporating vermiculite insulation of the stack.

Carbon Bricks and Tiles for Chemical Tanks

The resistance of carbon to chemical attack has suggested another use for lining tanks holding corrosive liquids, e.g. pickling tanks for steel sheet and strip, and paper pulp digesters. It is also useful for laying acid proof floors. Carblox bricks are also more resistant to abrasion than ordinary bricks and tiles used for the same purpose. As they are porous they must be laid with a special chemical resisting backing cement. Similarly a special jointing cement is required. These cements are used up to 300° C. and give a strong bond and are acid and alkali proof.

Technical Advisory Service

The firm maintain a technical advisory service to assist manufacturers in solving any special problems which may arise in the use of their products.

Continuous experiment ensures that not only is quality maintained, but also that progress is being made in improving the properties of existing products, and in introducing new ones to meet the needs of industry. That briefly seems to summarise the policy of the directors of this progressive firm.

Ceramic News from Scotland

THE clay pipe manufacturing industry in Scotland continues to work energetically and with a greater level of output than for many years.

Although the clay is manufactured in a wide range of types, including the clay-stemmed type, the demand and the aim of the industry is naturally towards a better type of pipe, which will compete with the briar. The problem involved here is to find suitable stems and ferrules which will meet the manufacturers' needs at a suitable price—for price is, of course, an important factor. The situation has varied somewhat from time to time, as supplies of mounts permitted a larger volume of activity and the whole trend in the industry—which is now mainly if not entirely located in Glasgow—is towards an expansion of output.

Lack of Recruitment

The depressing aspect of the situation is that this expansion is possibly only a temporary one. The manufacture of clay pipes is a highly skilled craft and few boys have shown any tendency post-war to enter the trade. In this, clay pipe manufacturing is no worse off than other craft industries. Boys tend to go into the mass-production industries, or industries which appear to have a future.

Clay pipe manufacturing, despite its undoubted virility at the present time, is working with older men. There would seem to be less apparent future from the viewpoint of the juniors, and there has been a consequent reluctance to take up this work. What happens when the present craftsmen retire is anyone's guess. Certainly clay pipes will still be wanted. How they are to be produced and whether it would pay to install mechanised plant, assuming that this were possible, is another matter.

More Elaborate Design

What is intensely interesting is the current revival of interest in older pipes, including clays. Tobacconists are again showing more elaborate clay designs, and were the fashion once successfully launched, the demand for clays would react accordingly.

Despite these problems, of raw materials, labour and changing demand, the clay pipe industry continues on a fairly satisfactory basis since the war ended and production was revived on a larger scale—and continues to add craft colour to an industry which has become increasingly a mass-production field.

Pottery Exhibition

An exhibition of Alastair Macduff's pottery was featured in Glasgow in M'Clure's Gallery, Wellington Street, recently, giving this Glasgow-born potter, now working in Edinburgh, his first major Glasgow show.

The eighty pieces exhibited were later destined for Heals', where some further additions were promised to bring the collection up to some 120 pieces. The collection demonstrated very clearly the fine quality of work which Macduff is now producing in Edinburgh.

His output is essentially designed for the collector, and is the work of a potter who is observing very high personal standards. The range covered punch bowls, vases, jars, dishes of all sorts, in a range of excellent greens, ivories, browns and heather mixtures. A feature of his work is the use of incised designs. Other items show moulded relief work, mainly of animal motifs.

Royal Scottish Academy Award

Mrs. Sinclair Thomson, who has received the Royal Scottish Academy Award of £25 for her "Girl in Pink," is the wife of Mr. Sinclair Thomson, who won the Guthrie Award two years ago.

Both are now working as artist potters in Glasgow, producing a wide range of tableware for the trade. Their output is being fully taken up and is regarded by the two artists as an alternative to their more serious work in their own field.

The Early Development of Enamels and Glazes

Origin of Enamelling

AN historical study of the art of porcelain enamelling reveals the strange fact that this art has manifested itself at different periods in many different forms, apparently with no relationship between them. In this respect, it varies widely from the quite generally established trend in the field of industrial arts where new materials, designs and processes come as the result of improvements over old ones—a natural step-by-step procedure. In enamelling, the art of the 14th Century differs entirely from that of the 12th, and the art of the 16th Century results in no way from the others. There we find three types of practices with no relationship and nothing in common between them excepting the material used—namely, the enamel and the metal base.

This is, without doubt, due to the fact that the art of enamelling, with the exception of the period beginning at the end of the 15th Century and lasting to the middle of the 17th, is not an independent art. It is, rather, a process of ornamental design which finds itself closely enlikened to the art of the goldsmith, which art it enriches by the harmony and splendour of its colours, but to which it remains, so to speak, subordinate. Nevertheless its importance is of such a nature that it occupies, justly, a place by itself among those beautiful industrial arts which are a joy to humanity.

Enamel and its Applications

Broadly speaking, there are four different methods of applying enamel to metals; in the first one, enamel filled into the metal is, so to speak, only an accessory to the ornament, the contours or design of which are formed by the metal itself. In the second, enamel covers the entire part of the metal that is decorated. In this case, it is translucent and the ornament, in low relief in the metal base, appears underneath the enamel. In the third, it is the enamel itself which covers the entire metallic base and which, by contrasts of colours, or even only by different shades of one colour, forms the painted ornament. In this case, the metal serves simply as an expedient—exactly like the canvas, wood, or paper in an oil, or water colour painting. Finally, in the fourth method, especially related to the art of jewellery enamelling, enamel applied to certain parts of the metal, is there only for the purpose of enriching the metal by its colour.

There are hardly any questions in the field of archæology which have given more cause for dispute than the question concerning the origin of the art of enamelling. Did the people of ancient times know the art in connection with the metals? The "electrum" of which Homer speaks in his Odyssey, Hesiodes in his description of the "shield of Hercules," and later, Sophocles, Aristophanes and the Greek in the translation of the Old Testament indicate that the ancients did know the art well. Was it the enamel we know today, which the artisans of the Byzantine Empire and the Middle Ages had used for decorating pieces of jewellery and for which the monk Thorplines had conserved the word "electrum," at the end of the 11th Century? This is the question which learned archæologists have discussed for a long time with equal merit but without succeeding, we must admit, in solving it in a satisfactory way. Both sides have supported their opinions by proofs which appear on

each side irrefutable, but which, based only upon words easy to interpret in different ways and according to the needs of the question, have, until this day really proved nothing in relation to the true meaning of the word.

No useful purpose will be served by entering into this deep discussion here, at least as far as it concerns the present times. But it is difficult, in view of the monuments in the glass cases of Louvre, those of the museum of Bentag, and those of the principal public collections of Europe, to refuse to Ancient Egypt the knowledge of the practice of the art of enamelling and the discoveries made in the tombs of ancient Etruria, particularly since it has been proved that the Greeks, too, knew how to enamel jewels of gold.

In Egypt

The Egyptians—whom one finds by the way, at the origin of all industrial arts—were extremely clever artisans in every field; we have seen that the methods they used in manufacturing and blowing glass were quite identical to those still used in the majority of our glass factories, and that they excelled especially in manufacturing from glass pastes coloured by means of metallic oxides and made opaque by the addition of tin oxide. Those small oil bottles, those perfume flasks and those amulets of various forms, by the perfection of their structure and the variation of their colours, continue to excite the admiration of our most skilled specialist craftsmen. There exists no difference in composition between those pastes and the ones used by enamellers at any time in the practice of their art.

If we examine certain jewels in possession of the Egyptian museum of the Louvre, we find that, in the ornamentation of several of those jewels, diverse colours were used, separated from each other by metal partitions.

In one of these gold jewels which pictures a hawk with the head of a ram, we find the exact method of separating the pastes by means of fine gold blades which are soldered upon the base and fastened to stronger partitions of the original metallic base. there we have, at least as to methods of execution, and without any modification, the Cloisonne type of enamelling supposed to have been developed later (early Cloisonne enamelling was dealt with in detail in the May issue of CERAMICS).

Greece Etruria

The Etruscans, in whose arts and industries one finds again such an obvious oriental influence, knew the most difficult practice in the art of enamelling. Of this, there can be no doubt, because we find ourselves confronted with monuments before which it is impossible to raise the slightest objection. There exists indeed, in the Louvre in Paris a large number of the most remarkable objects found in the tombs of ancient Etruria, ornamented with true enamels, whose colours of exquisite delicacy and harmony are witnesses of the fine taste and extreme skill of the artisans who executed them.

The most important piece is a magnificent Greek-Etruscan diadem, consisting of an assemblage of small, more or less carved gold blades, held together by a strip stamped out in semi-circular form, which adorns the entire lower part of the diadem. The entire frontal surface is covered with various ornaments executed with the greatest elegance and fixed upon gold blades. At about the middle of the height, extending over the entire width of the diadem, one sees a number of small daisies, whose centre is adorned by a pearl of glass paste, surrounded by other smaller flowers and by leaves enamelled in white, blue and green.

A multitude of ornaments of the same type, enriched by enamels and pearls of glass paste of very soft tone, cover the entire remainder of the surface. In addition to the diadem, which may be considered a monument of unique and almost inimitable jewellery, are seen ear ornaments almost all of which take on the form of birds—dove, peacock, rooster or swan—with the body in white enamel, wings and head of different colours, suspended from rosettes, ornamented by enamels. Two golden miniature figures of women, likewise of very archaic style, whose eyes, diadems and necklaces are enamelled, prove that the Etruscans have practised the art of enamelling since the earliest times.

It is then quite evident that the ancient people, especially the people of the Orient, were acquainted with the art of enamelling. But they had lost it or at least abandoned its practice

for such a long time that, before the very late discovery of Egyptian and Etruscan jewels of which a description has been given above, and in the presence of so many enamelled objects found almost everywhere on the soil of old Europe, one might easily have believed that the birthplace of the art of enamelling was Ancient Gaul, Great Britain and Germany.

It is certain that at the time of Pliny (eighty years after Christ) enamels were not known to the Roman world and that more than 100 years after him, Philostrates, the Greek rhetorician, who had come to Rome at the beginning of the 3rd Century, spoke of them as a type of ornamentation characteristic of the people living close to the ocean. "Those colours," he said, "are spread by the barbarians of the ocean, it seems, upon heated brass; they stick to it, harden upon it and retain their design." The commentators of Philostrates have interpreted those words in different ways, but most of them, among others, Blaise de Digenems, have recognised in them the enamel: "For the barbarians inhabiting the shores of the Ocean know how to place them down (so they say) upon copper coming red hot out of the fire and on which later they chill and turn into enamel as hard as stone, preserving distinctly the design which had been smeared upon it." In another passage Philostrates also speaks of silver bits "trimmed with Celtic ornaments."

Early Enamelling in France, England, Scotland and Germany

The relatively large number of enamelled objects, and especially small pieces—possibly parts of the harness of horses found at the time of excavations carried on recently in France as well as in England, Scotland and on the shores of the Rhine, in tombs dating back to the first centuries of our era — has come to confirm the allegation of Philostrates. It is, however, impossible to determine with certainty the place of manufacture of those different objects which may attribute to all nations of Celtic origin who lived close to the Ocean as well as to the industry of Nomadic tribes.

It is known, however, that the art of enamelling was practised not only on the shores of the Ocean, but in the very heart of Gaul, home of the Eduens, previous to the Christian era and consequently at least two centuries before the time of Philostrates. The excavations carried on in 1869 on the mountain site of ancient Bibrack, the main fortress of the Eduens, Caesar's most important fortification, led to the discovery of a great many shops where they worked largely with bronze, among them a few shops in which the industry of enamelling upon metal was practised. The tools were lying around in great disorder, say the authors of this important discovery. The ovens (hearths) were still filled with coal, and beside completely finished articles could be seen others hardly outlined, again others in the midst of making. One was even enveloped yet by burned clay. Everywhere were pieces of coarse enamel, earthen melting pots, polishing stones, considerable waste matter, metal chips, leavings resulting from the cutting, vitreous shells which conserved the impression of the bronze designs, and above all, the very witness of their activities—a true relic of French soil, medals that fixed the age and period of the pieces.

The shops discovered in these conditions seemed to have been destroyed by a violent fire, and the unfortunate artisans had to flee hurriedly, taking with them only their most precious possessions. Nevertheless, the articles found in the excavations of Bibrack area, in spite of being of little importance, are of great interest from the point of view of archæology. This is especially true because they show that before the Roman invasion (all the discovered medals are exclusively Gallic and contemporary of Caesar—these medals are now in the museum of Saint Germainy) the art of enamelling was practised in Gaul.

Already at that time, as later on at the time of Philostrates, the majority of those enamelled bronzes seem to have been destined for the harness of horses. They are in general, ornamental round pieces or studs to be placed on the frontal piece or other parts of the harness.

These are only the first revelations, quite imperfect and rather crude, of an industry, implanted in the Gauls nobody knows how. The industry has produced works of a much more advanced technique, and specimens of

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the higher art are found everywhere in Europe.

However, if one compares the different enamels of which samples are found in Hungary, on the shores of the Rhine River in Denmark, in Great Britain and in ancient Gaul, all of which samples show the same method of manufacture and, with a few slight differences, the same principles and the same style of decoration, one is forced to admit that these enamels have been manufactured by nomad artisans, of unknown origin but probably oriental. These artists carried their furnaces from country to country, much as it was done in the same period by the makers of pottery.

Mixed Types of Enamels

The movement of renovating the art of enamelling in Germany so happily begun under the influence of Empress Theophanie, was to be emphasised still more vigorously under Henry II (St. Henry) who also governed the empire of the Occident from 1002 to 1024.

It was then that the German goldsmiths thought of substituting copper for gold, almost exclusively used by the Greek. This enabled them to give a more important place to the enamels they brought into the ensemble of their decorations and at the same time, lowered price. Moreover, by enlarging their enamelled plaques, they removed a part of the difficulty of execution.

Champleve Enamels

The process of the true Cloisonne style was soon abandoned, at least for the design of figures, in order to be replaced by a different more speedy method, which was to cut the cloisons into the metal itself.

The figures, cut into the metallic base, are wholly enamelled in shaded colours. Among the most beautiful examples of pieces belonging to this first period of champleve enamelling are the figures of prophets and the medallions which adorn the shrine of St. Ebert, in the church of Dantz, a suburb of Cologne. This magnificent shrine, dating from the first half of the

12th Century, has the shape of a rectangular coffer surmounted by a top with two slopes and on each one of its walls we find six statues of apostles carved in silver, separated by columns, each one of which supports the wholly enamelled figure of a prophet. These columns connect with enamelled bands which divide the two slopes of the top into six bays, the fields of which are decorated with beautiful leaves in silver and circular medallions showing in enamels of different colours subjects taken from the legend of St. Enbert.

From Cologne, the art of enamelling spread through the cities situated on the shores of the Meuse river as far as Verdun.

Limoges School

It is from this moment on that the manufacture of enamels developed in France.

From the 13th Century on, the ornamentation of jewellery by the means of inlaid filled-in enamels expanded considerably. One may presume that in all cities with goldsmith's shops, this type of decoration was practised; nevertheless, Limoges was the main centre of this industry and its products soon acquired such a reputation that the art of enamelled jewellery took on generally the name of *"ouvrage de Limoges"* or *"veuore de Limoges,"* no matter what was otherwise the origin of the object; numerous examples as to this point are found in the record of this epoch.

The art of enamelled jewellery was highly appreciated in foreign countries especially in England and several Limonsine artists were called there for the execution of enamelled tombstones.

Translucent or Basse Taille Enamels

Instead of imbedding enamel between cloisons, which necessarily gave to the figures a stiffness and heaviness, Italian goldsmiths used it to produce a type of enamelling which became known as "translucent" or "basse taille."

In this new process, carved metal was covered with coloured enamels. The artist sketched his design in a gold or silver plaque, carved it in half relief and then put on the plaque a layer of translucent enamel in powdered form which, melted in fire, covered the carving with a sort of coloured glaze.

Quite apparently, this type of enamelling was used for the first time in Italy in the course of the 13th Century. Its discovery is attributed to Jean de Pise (1250-1328).

Translucent Enamels Cloisonne Ajour

Sometimes called "plique ajour," this type of enamel, probably on account of its difficulty of execution, was not made extensively. Citations in history are rather rare. Here the coloured enamels are placed between cloisons that are not fastened to metal, and fired. The whole, when completed, is transparent, resembling, when held to the light nothing so much as a tiny stained glass window. The cup of Cosroes I, King of Persia (d. 570) which was later called the "Cup of Solomon" answers the description of this type of enamelling, although it is not made of enamels, but fragments of translucent coloured glass, inserted between metallic cloisons. As this cup, of Persian make, dates back from the 6th Century, it must be assumed that this type of work, first practised in the Orient, passed from there to the Occident and that coloured glass, after the introduction of the art of enamelling in Europe, was replaced there by translucent enamels.

BRITISH STANDARDS

THE Monthly Information Sheet, for April, 1950, issued by the British Standards Institution, 24/28 Victoria Street, London, S.W.1, contains the following which will be of interest to readers:

New Overseas Standards

Rumania.—STAS 126 Refractory products—compression test; STAS 130 Refractory products—classification; STAS 133 Refractory shapes; STAS 134 Refractory mortar for refractory clay bricks; STAS 135 Refractory silica products; STAS 136 Refractory fire clay products; STAS 230 Common clay for blocks and tiles; STAS 231 Refractory clay for fine and coarse ceramic products; STAS 266 Dolomite, calcite and white marble for glass and fine ceramic products; STAS 268 Felspar for fine ceramic and glass production.

Safe Handling of Fluorine

In view of the fluorine problem in the Ceramic Industry, this general discussion will be of interest.

FLUORINE is the most electronegative of all of the elements; there are no oxidising agents strong enough to liberate it from its compounds. Consequently, fluorine can be liberated only by electrolytic methods in a rather specialised cell. It is made at only a few places in the world, and, contrary to impressions which may be gained from the popular press, it has not been responsible, so far as reliable reports show, for any industrial accidents. However, it is a hazardous substance. One source of confusion in the press is the failure of reporters to distinguish between fluorine and hydrogen fluoride. Elemental fluorine can be made to combine directly or indirectly with all of the elements except the inert gases. Combined fluorine always exists in the minus one valence state, as fluoride.

Raw Materials

The raw material from which most of the fluorine compounds are made is fluorspar, or calcium fluoride, a rather widespread mineral. However, good deposits are quite scarce. By heating fluorspar with sulphuric acid, hydrogen fluoride is made. It is sold as a liquified gas in pressure cylinders as anhydrous hydrogen fluoride, or as hydrofluoric acid, which is a water solution of hydrogen fluoride. From this acid almost all of the fluorine products are made.

Physiologists have shown by animal experiments that fluorine may be one of the necessary trace elements for good health. Rats raised on a fluorine-free diet were in poor health in a few weeks and were not able to bear young. It has been shown that drinking water containing fluoride has a beneficial effect on the teeth of children. A rather significant reduction in the incidence of dental caries has been observed and reported for regions where the drinking water contained at least 1 part per million of fluoride. At still higher concentrations of fluoride ion, the structure of growing teeth may be changed, so that the surface develops a mottled appearance. Mottled teeth may still be strong and healthy and, while they may be somewhat more brittle than the normal tooth, they have a tendency to resist decay.

Effects at Higher Intakes

On close study, no other chronic effects attributable to fluoride ion were noted in an area where the drinking water contained fluoride. At still higher intake of fluorides over a period of many years, clinical examinations of industrial workers have shown that the bones of the body are affected, without disabling the worker. When fluoride it taken in rather high concentration, chronic fluorosis may appear in man, although the exact level of intake at which this occurs is not well documented. Certainly the large percentage of fluoride ion absorbed is excreted. Intake as high as 20 to 30 milligrams per day of fluoride may be tolerated over rather long periods of time without producing any chronic effect, or visable change in bones and teeth of adults. When fluoride is ingested in such large quantities, about 90 per cent. is eliminated at once, and at least part of the remaining 10 per cent. may be eliminated slowly from the body over a long period after ingestion. These figures are quite well documented and would indicate that although fluorides are regarded as a general protoplasmic poison, they do not act as a chronic poison on man when their intake is limited to about 10 milligrams a day. Their effect is altered according to the chemical compound and the

amounts involved in the specific exposure. Therefore, a discussion of some of the hazards of the individual fluorine compounds is in order. For this purpose a division into classes is convenient.

Insoluble Fluorides

The water-insoluble fluoride salts will be considered first. Fluorspar and cryolite, the only common members of this class, are found as minerals. Fluorspar has already been mentioned as the important source of fluorine, while cryolite is only a minor source and, in fact, some cryolite is made synthetically from fluorspar. Because of their low solubility, fluorspar and cryolite have low toxicity. They are nonirritating to the skin, and when inhaled even in relatively large amounts will not cause much coughing or irritation. It has been reported that when inhaled they are slowly absorbed to produce chronic poisoning or fluorosis. The reported symptoms of fluorosis, besides the bone changes as revealed by X-ray are anorexia, vomiting, constipation, dyspnea upon exertion and rheumatic pains. These reports on chronic poisoning are not too well documented, however, and more recent work would indicate that a large part of the fluoride absorbed would be eliminated, and as pointed out before considerable amounts can be tolerated in the body without chronic effects. The lethal dose for the insoluble fluoride must be quite large, and this type of poisoning cannot be considered an industrial hazard. Many of these insoluble fluorides are used industrially for their fluxing action on other substances. When they are so used at high temperatures it is possible that they may have sufficiently high vapour pressure to cause fluorine poisoning; however, authenticated cases of such poisoning have not been reported in the available literature.

Soluble Neutral Fluorides

The soluble non acid-forming fluorides are the next to be discussed. This class would include some of the fluorides and some of the complex compounds of fluorine such as the fluosilicates and the fluoborates. These compounds are widely used in the ceramic industry, the electroplating industry, and the laundry industry. The dry salts of these compounds or their neutral solutions in water will not burn the skin. When the soluble fluorides are inhaled as dusts, they are readily absorbed. Within limits, urinary excretion may be expected to take care of the fluoride so absorbed. It has been shown that over 10 milligrams of sodium fluoride may be ingested daily without storage or harmful effects. The urinary excretion may be used as a measure of fluoride inhaled or ingested, and it can be used as an index to show when toxic limits have been exceeded. Acute poisoning from sodium fluoride taken orally is of rare occurrence in industry and results almost entirely from accidental ingestion. A lethal dose varies from 5 to 15 grams when taken by mouth. It produces severe cramps, with stomach and intestinal hæmorrhages which progress to death from shock. Small amounts of sodium fluoride may be swallowed by industrial workers working in a dusty atmosphere aand may cause minor nausea and vomiting. A careful study of workers exposed to sodium fluoride vapours coming from an open hearth furnace failed to show any chronic effects that could be attributed to such vapours. The toxicity of the soluble fluorides varies greatly. Recent unpublished work has shown that the fluoborates are eliminated much faster without toxic effect than either the fluosilicates or the fluorides.

Acidic Fluorine Chemicals

The third class of compounds to be discussed is that of the acids and the acid forming compounds. This class includes hydrofluoric acid, fluoboric acid, fluosilicic acid; and for convenience, this class also includes the salts of these acids that hydrolyse in water to form acid solutions. All of these compounds are extremely corrosive to the skin, especially water solutions of the salts and acid. Skin changes caused by exposure to these compounds range from minor burns to serious ulcers which heal very slowly. Blisters are fairly common and loosened finger nails are said to occur. Hydrofluoric acid is by far the worst offender of this group. In experimental animals, the inhalation of hydrofluoric acid gas in sufficient

concentration usually causes fatal edema of the lungs. Experience has shown that the fatal vapour concentration for a man in good health is so irritating to the eye and to the upper respiratory tract that the only way a lethal dose of the acid fluorides could be received by inhalation without ample warning would be by a sudden inhalation of a high concentration of the acid compound as a fine spray or dust. Several such accidents have been reported. However, it is inadvisable to place full reliance on this warning given by the eyes and nose, as workers suffering from anæmia or cardiovascular diseases might well succumb to circulatory collapse or pulmonary edema after exposure to concentrations which are not too irritating to the eyes and nose.

Industrial Hazards

Years of experience in the manufacture of fluorine chemicals have shown that these materials can be handled with relative safety, providing their hazards are recognised and the necessary precautions taken. Any process that is using fluorine chemicals should be carried out in an area that is well ventilated. This applies to the solid, insoluble fluorides as well as to the acid gases. If any large amount of fluoride gases or fluorides has to be disposed of, the material should be reacted with lime, converting the fluorine content to insoluble calcium fluoride, which can then be disposed of in the ordinary way. Small quantities of the fluorides could be disposed of by venting to a high stack; however, this procedure is to be avoided whenever possible. The extremely active fluorine gases can be disposed of conveniently by burning them with a hydrocarbon. This produces carbon tetrafluoride and hydrofluoric acid. The resulting gas mixture is then scrubbed with a water lime mixture and the resulting calcium fluoride can be disposed of as a harmless solid. Unreactive gases can be vented without harm to personnel. Workers in operations involving exposure to fluorine compounds that are acid or acid-forming should be selected initially by medical examination. No worker with a doubtful chest X-ray or suffering from asthma or other pulmonary complaint, or from cardiovascular disease, should be employed in such operation. Where it is necessary to work with complete protection, including rubber suits, it is important that the worker should have a cardiovascular system with completely normal response to exercise. Otherwise, serious circulatory collapse can result merely from interference with heat transfer of the body due to the impermeable rubber clothing. Before anyone is allowed to work with any of the acid and acid-forming compounds, they should be provided with the proper safety equipment to carry out the work they are to perform. If possible, the same men should always be assigned to the work, and they should be thoroughly instructed regarding the hazards involved. It is very important that each worker be assigned his own protective clothing and be instructed in how to keep this clothing clean.

Working with Hydrofluoric Acid

The following clothing has been found practical for work with hydrofluoric acid and should be easily adaptable to any work where soluble acid fluorides are involved: gauntlet style neoprene gloves, eye shields with large 8 in. visor; a chemical respirator with cartridges for acid gases; acid-type neoprene aprons; safety goggles, which for those men who wear glasses, should be special coverall goggles to fit over the glasses. If the worker is to go into an area contaminated with high concentrations of hydrogen fluoride, he must be completely protected by a neoprene suit which is provided with a gas mask of the hose type. It is quite important that each workman be provided with neoprene-sole safety shoes.

The release of fluorine chemicals, whether accidental or otherwise, may leave a film of acid on any object contacted, and touching these objects will result in an acid burn. In any area exposed to any soluble fluorine chemicals, cotton or canvas gloves should be prohibited, as such gloves are easily contaminated with the solid fluorine compound which can be hydrolysed to form hydrofluoric acid and then would penetrate through the glove and cause a serious burn.

Protective measures against fluorine and the halogen fluorides are not

fully developed, and entry into zones contaminated with these compounds should be avoided. Only airline or oxygen masks can be recommended for personal protection against these compounds at the present time. Neoprene gloves and face shields can give only temporary protection against fluorine and the halogen fluorides and if brought in local contact with fluorine at high concentration, they will inflame. Therefore, safety clothing can give very little protection against such compounds. When working with elemental fluorine at elevated pressure some rather strict safety precautions have been developed. Any apparatus that is to contain fluorine under pressure should be surrounded by a protective barrier of steel at least ¼ in. thick, and all valves should be operated by remote control. Such vigorous precautions are not necessary with fluorine or the halogen fluorides when used at low pressures.

First Aid

In spite of elaborate precautions there will be an occasional accident when working with fluorine chemicals. When such accidents occur, the speed in removing the patient from the area and application of first aid will, in many cases, determine how serious the accident will be. The following is a brief summary of the most recently recommended first aid treatment for the most common of the accidents likely to occur, that is, hydrofluoric acid burns. The area of the worker's body that was in contact with hydrofluoric acid should be immediately washed with large quantities of water. Following this, an ice-cold saturated solution of magnesium sulphate or iced 70 per cent. alcohol should be applied for at least 30 minutes. The physician should be on hand to administer treatment before the completion of the magnesium sulphate or alcohol treatment. If, however, he has not arrived by that time, it is then permissible to apply a generous quantity of paste made from powdered megnesium oxide and glycerol. For many burns this is the only treatment required; however: for the more serious burns the physician may want to prevent further penetration of fluorine ion by the injection of calcium gluconate. While immediate attention must necessarily be given to the removal of hydrofluoric acid from the skin of exposed workers, the acute exposure to hydrofluoric acid can also lead to shock and circulatory collapse. Therefore, those assisting the worker to wash hydrofluoric acid from his body should watch very carefully for signs of such collapse.

Eye Injuries

If liquid hydrofluoric acid has entered the eyes or if the eyes have been exposed to strong concentrations of the vapour, they should be irrigated immediately and copiously with clean water for a minimum of 15 minutes. The eyelids should be held apart during the irrigation to insure contact of water with all the tissues of the surface of the eye and lids. A physician, preferably an eye specialist should be called in attendance at the first possible moment. If a physician is not immediately available, the eye irrigation should be continued for a second period of 15 minutes. After the first 15 minute period of irrigation is completed, it is permissible, as a first aid measure, to instil two or three drops of a 0·5 per cent. pontocaine solution or an equally effective aqueous topical anesthetic. No oils or oily ointments should be instilled unless ordered by the physician.

Ingestion of hydrofluoric acid or of the soluble acid fluorides is not a common accident. Such compounds cause severe burns of the mucous membranes of the mouth, throat, and stomach. Here, copious irrigation is not feasible, and no attempt should be made to pass a stomach tube except by the attending physician. The patient should be encouraged to drink a large quantity of water without delay. After the hydrofluoric acid has been diluted with water, white of eggs or mineral oil may then be administered for their soothing effect. The patient should be carefully watched for signs of shock or circulatory collapse.

A worker who has been suspected of a possible severe exposure to gaseous hydrofluoric acid should be carried at once to an uncontaminated atmosphere. Even in the absence of symptoms, a worker must not be permitted to return to work for at

least 24 hours after a suspected exposure because of the potential danger of developing severe edema of the lungs. A physician should be called immediately and, if a trained attendant is available, the administration of oxygen should be started at once. The attending physician will take care of the medication; however, when adequate oxygen is supplied in the manner prescribed, all distress which accompanies suspected exposure to hydrofluoric acid gas will usually disappear. A mild sedative, such as aspirin or sodium bromide, may be given if thought by the physician to be desirable. Since morphine depresses the respiratory centre, its use in suspected hydrofluoric acid gas exposure merely handicaps further an already embarrassed respiratory system. Therefore, morphine should never be given. This information has recently been distributed.

If sufficient fluoride ion has been absorbed by the blood stream, the blood calcium may be lowered to a dangerous level. In such cases the patient would suffer from shock from this cause, and the immediate administration of calcium gluconate intravenously is required. Nothing should be given by mouth to an unconscious patient.

To summarise, one of the first things to recognise in the safe handling of fluorine chemicals is the specific hazard involved. This hazard may have been over emphasised in the past. In small amounts fluoride may be necessary for good health. In high concentrations it is definitely toxic; however, the symptoms are pronounced and easily recognised, and, after the original effect has passed, chronic symptoms are rare. Therefore, in handling most non acid fluorine chemicals, if adequate protective clothing is worn and proper ventilation provided, there is little danger of any serious industrial hazard from these chemicals. The daily absorption of fluorine by industrial workers can be determined quite closely by urinalysis, while fluorine absorption by the worker over long periods can be determined by X-ray studies. Both methods will indicate excess absorption long before serious harm is done. Hydrofluoric acid and acid-forming salts present an additional hazard in that they can cause rather serious burns, often without adequate warning symptoms. However, when this hazard is recognized and first aid treatment is readily available, the dangers of these burns can be greatly minimised.

(*Ref. Chem. and Eng. News*, 27, 52, 26th December, 1949, pp 3854-7.)

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Development in Kiln Furniture

by

JOHN WALKER, A.R.S.M., B.Sc.

KILN furniture has received much careful study in the pottery and other industries and in recent years several influences have given impetus to fresh study; for all this the industry being essentially a practical one, will not make the mistake of depending solely on laboratory work for progress.

In these days of tunnel kilns, no potter is going to accept either "trial and error" or laboratory work alone as the means of selecting furniture for his particular conditions. Scientific work must, therefore, go hand in hand with practical developments.

Development of Open Settings

The interest in kiln furniture is most strongly directed to open settings. The chief tasks in this field are to:

1. Produce materials having much greater hot stength and adequate resistance to thermal shock and dunting.
2. Fashion from these materials furniture designed to improve efficiency by allowing a bigger proportion of the kiln setting space to be filled with the ware to be fired.
3. Reduce to a minimum the time required to place and unload ware.
4. Eliminate deficient furniture as a cause of sub-standard ware.
5. Minimise marks on the ware due to contact with the furniture and thus reduce the necessity for post-kiln operations to remove them.

Furniture Design

Though it is not proposed to assess the merits or demerits of any particular designs, it may be useful to indicate the directions in which a study of first principles may lead to a truer evaluation.

Of first importance is a good stable level deck on which to rear any desired superstructure. No doubt many potters have had encouraging experience with decks made with refractory concrete, but others who may have been discouraged by the limitations of existing materials, will be interested to know that recently marked improvements have been made, the results of which should soon be commercially available in this country.

Reduction in the thickness of props and other supporting members, accentuates the need for stability in the furniture assembly. It is all so easy to build up an over-rigid structure and to give insufficient consideration to the need for the whole assembly to breathe freely.

Design possibilities must be related to the improved methods of manufacture now being used, but in view of the relatively coarse textured highly grogged mixtures used by refractory makers, it needs to be emphasised that these have poor flow properties. Would-be designers of open setting furniture should, therefore, be sympathetic to requests for design modifications intended to promote an even flow and distribution of the material.

Extrusion of constant section shapes is an attractively economic method, but with this method it is essential to avoid design features such as excessively sharp corners or sudden changes in sectional width and thickness.

Practical Approach

Hitherto, the selection of furniture designs, dimensions and materials, has almost entirely been done by rule of thumb. An era is now beginning when ceramics will be regarded as an engineering material, in the selection of which, specifications similar to those published and used for other constructional and engineering materials will be demanded. Steady progress

Summary of Paper given to The British Ceramic Society, Stoke-on-Trent, 13th March.

is being made towards making this approach practical in the case of kiln furniture.

As an essential start, a few basic requirements are now receiving the attention they deserve. These are:

(a) Improved homogeneity and generally improved consistency of physical properties in refractories "as delivered."

(b) Their much greater stabilisation, even under prolonged exposure to the temperature of use.

(c) Development and use of adequate methods of measuring hot physical properties.

The other factors involved are (i) payload; (ii) area of batt; (iii) thickness of batt.

"R" the payload ratio, as shown in Fig. 1, can be considerably increased by reducing the area of the batt even after allowing a reasonable reduction in the batt thickness. If a 12 in. square batt has a payload efficiency just over 2, a figure exceeding 3 is obtainable with a batt 10 in. square. In practice, of course, a complication arises from the presence of props and from the limit to the amount of ware which can, in fact, find room on the batt.

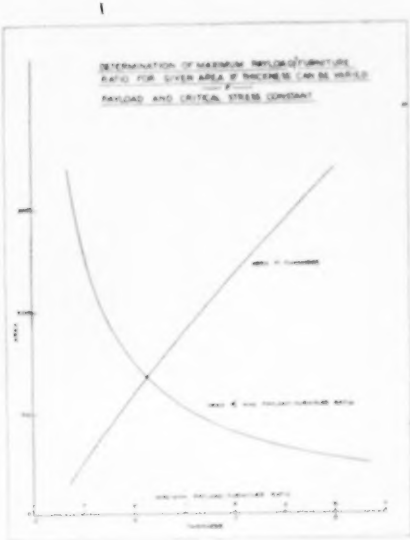

Fig. 1

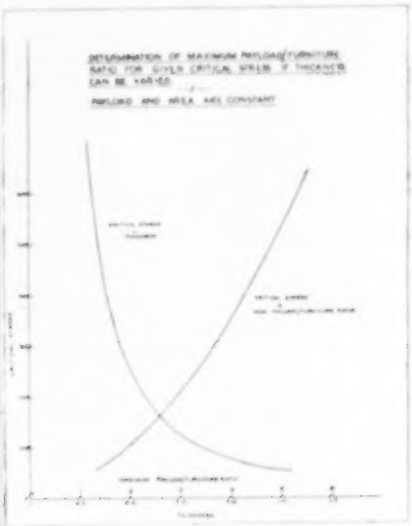

Fig. 2

(d) Mathematical study of stresses and strains in service.

Little has been published in the way of mathematical studies of kiln furniture design, but their scope as a useful guide to development can be illustrated by a few general curves and data obtained from a study of batt design.

Assuming the batt material possesses ordinary elastic properties, two design parameters are required, namely:

Sc—the critical stress. This is a characteristic of a given material and is the stress which if exceeded in any part of the batt will lead to failure.

R—the payload furniture ratio. The weight of the ware carried by a batt divided by the weight of the batt itself.

Fig. 2, relating to a batt of fixed area carrying a fixed load is probably the most interesting. It shows that the ratio by which the batt thickness can be reduced by increasing the critical stress is only about the square root of the ratio of the critical stresses. For example, a four-fold increase in critical stress from 100 to 400 lb./sq. in. will permit a reduction in thickness only from 0·68 to 0·3 in. Nevertheless, the payload furniture ratio increases from 1·95 to 4·3.

The value of building up data in this way will be readily appreciated. Not only can the development of the most efficient batt assemblings be

worked out on a logical basis, but risks need not be taken blindly in an effort to increase the payload furniture ratio.

Furniture Refractories

Most of the refractories concerned in the development of open setting kiln furniture, consist, after firing, of varying amounts of crystalline material, such as mullite, embedded in or bonded by a matrix of glass.

Achieving a high hot strength is thus primarily the problem of making a material which is wholly crystalline or of which a high proportion is a crystalline constituent adequately held together by the minimum amount of a glass of the highest possible viscosity at the temperature of use or test. Amongst the most suitable crystalline constituents are alumina and mullite. Generally, the viscosity of aluminosilicate glasses is greatest when the alumina content is as high as possible and the impurities, alkalis, alkaline earths, iron oxide, etc., minimised.

Measurement of Hot Strength

Numerous methods of measuring hot strength have been devised and their comparative advantages described elsewhere. Reference here will be limited to tests evolved for refractories subjected to bending loads and to three kinds that are in regular use. These are:

1. Measurement of creep rate with the load and temperature fixed.
2. Measurement of the amount of permanent deformation, bend or sag, the load, temperature and time of the test being fixed.
3. Hot bending strength.

In all these tests, the sample is supported on two knife edges and the load applied centrally. In the measurement of creep rate, the test piece is unloaded while it is being raised to the required temperature. Then the load is applied and the *rate* of sag measured.

A few results will illustrate the use of this apparatus. Table 1 gives the creep rate at 1,000° C. lb./sq. in. of four fine textured materials, such as might be used in the manufacture of supports. Table 2 refers to a straightforward clay bonded sillimanite mix such as might be employed for batts and the results of testing the same material for four hours at 1,250° C. under a load of 140 lb./sq. in. are given in Table 3, which shows the effect of raising the firing temperature.

Though it is interesting to note the marked benefits secured in the hot strength and resistance to sag of even a very ordinary clay/sillimanite mixing

TABLE 1

Body	*Chemical Composition*	*Structure*	*Creep rate* 10^{-6} *in./in./hour*
A	Alumina	Crystalline	0·27
B	Mullite	,,	0·34
C	Alumino-silicate	largely crystalline	16·6
D	,,	Mullite with appreciable glass	1,060·0

TABLE 2

Firing temperature	*Test load*	*Creep rate* 10^{-6} *in./in./hour*
1,500° C.	150 lb./in.^{2}	166
1,650° C.	,,	39

TABLE 3

Material	*Firing temperature*	*Breaking Strength lb./in.*	*Average permanent deformation or bend* 10^{-4} *in. on 2½ in. span*
Clay bonded sillimanite	1,500° C.	1,070	17
,,	1,500° C.	1,110	11
,,	1,650° C.	2,310	3
85% silicon carbide mix	—	3,730	3

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by raising the firing temperature, the best results are, of course, obtained by modifying the material to take full advantage of the improved kilning.

Dunting and Thermal Shock

The exact mechanism of dunting is perhaps not so well understood as we used to think and further confirmation is required as to the relative importance of the properties which provide a refractory's resistance to failure in this way. It has not yet been possible to develop any practical tests simulating service conditions even as good as the panel spalling tests now frequently used for firebrick.

With regard to development work undertaken to improve the resistance of refractories to dunting, some conditions are worth mentioning briefly although they may be already well known.

Firstly, it should be emphasised that high temperature kilning for furniture is in itself not a cure-all and, in fact, if materials are not adjusted to suit such kilning, dunting resistance may be reduced.

Secondly, a low co-efficient of expansion is desirable and sometimes extremely useful.

And thirdly, refractories, to have good dunting resistance, should be very homogeneous and of uniform density.

Present Trends

However, the user is less interested in what *can* be done than in what *is* being done.

New, modern refractory plants are being erected in this country, functionally designed for their intended purpose, embodying not only the latest mixing and shaping machinery, but continuous kilns capable of operating at the highest commercial temperatures.

In parallel with progress in process and plant, however, active steps are being taken to introduce the, perhaps, rather overdue closer control without which the best plant may substantially be wasted.

In conclusion, the author wishes to express his indebtedness not only to members of the Central Research and Refractories Department of The Morgan Crucible Co. Ltd., but to many others whom it has not been possible to acknowledge specifically.

American Commentary

New Ideas and Technical Development

STAFF REPORT

OUR western friends provide another interesting selection of news and ideas for this month. First from the bag is a report of a new application of an existing plant —the pressure-patching of cupola linings.

In most foundries, the cost of relining cupolas constitutes a significant item because both labour and refractories required are expensive. Conventional relining is by hand application and ramming of the patches.

In such work, patches of ganister/clay more than 2 in. thick are not recommended and, as patches up to 12 in. thick are often needed, bricks have to be added. The time for this style relining, including chipping out slag, coke and oxide was about 30 hours. In seeking to reduce this, one American plant decided to experiment with a Bondact gun, fed from a dry mixing device termed a Bondactor.

Operation Details

Water, plus compressed air (for atomising), are added at the gun along with the stream of refractories which is fed from the Bondactor. Identical equipment has long been used elsewhere for applying layers of concrete in construction work.

Using this equipment, a wet stream of refractories is made to issue from the gun at high velocity. It is the muzzle velocity that packs or rams the refractories. No hand ramming is required but it is necessary first to chip out the areas to be patched just as is required for hand ramming.

After the surface has been so prepared, the gun is used to apply the necessary coating which can be made of any desired thickness up to 10 in. or more. This is partly because of the high density produced by the impact, especially of coarse particles, and partly because the moisture content is controlled and kept low. In practice, an average thickness is about 6 in. Tuyeres are plugged during application of the refractory. The new technique makes possible the use of the most modern design in contours and these in themselves reduce refractory costs from 20 to 40 per cent.

The only hand work required is that

Pressure-patching of cupola linings

of directing the gun and adjusting the water flow by a cock to give the desired water content. If the mix is too dry, dust is formed. If excess water is added, the application becomes too wet and runs.

Each particle strikes at high velocity and rams those beneath. About 90 per cent. of the total sticks, and what rebounds is chiefly coarse ganister. That which falls below is collected and is re-used so that there is practically no waste.

Because of the rebound of the ganister, the lining deposited contains a higher percentage of clay than in the mix being fed. Thus, when four parts of ganister to one of clay are fed, the lining deposited contains about three of ganister to one of clay.

Best Patching Mix

Different proportions of dry ingredients for patching have been tried but, to date, the best results have been secured with a 2 : 2 : 1, by volume, mixture of round coarse ganister, fine silica sand (or finely crushed ganister) and high quality clay.

It is important to use a highly refractive clay of maximum plasticity. If of proper quality, clay can range from 15 to 25 per cent. of the dry mix.

As the gun delivers 100 lb. of mix a minute, the operator has to keep in close touch with the operator of the Bondactor which is in a separate room at the far end of a 60 ft. hose. This he does by a pushbutton connected to a signal buzzer. Air and water cocks are at the gun, where the hose lines join the hose containing the dry grog.

The grog is stored in an overhead hopper and falls from the hopper into the upper of two conical containers. When this container is filled, its cover is closed and compressed air admitted. As soon as the pressure builds up, the passage to the second container, already under pressure, is opened and the charge transferred to the lower cone. Then the connecting passage is closed and the upper container opened and refilled. Thus, mix is always feeding into the supply hose as long as the machine runs. The two containers have rotating elements to keep the grog agitated and properly mixed. Consequently, the hose is kept filled with a uniform mix under air pressure of 75 p.s.i.

The close control and low moisture content are significant in that they make for uniformity not attained in hand ramming. In the latter, moisture varies from 8 to 20 per cent. If it runs, as it may, around 15 per cent., there are 300 lb. of water to be evaporated per ton of lining and some 3,200 gallons of steam must be driven off for each cubic foot of wet mix applied. Formation of so much steam may loosen the lining.

The mixture applied by gun has resulted in a better lining and in a closer approach to uniform cupola performance. There is less burnout and, consequently, less material needed in patching. Because the gun operates with a uniform mix and a substantial constant velocity of mix is attained, the degree of ramming remains nearly constant as does the water content.

Advantages

Investment in equipment is not large and the space needed for it is small. It is claimed that savings achieved will soon defray the initial cost.

Specific advantages claimed are as follows:—

1. Patching time is reduced to an average of about 60 min., including the wet.

2. No bricks are needed, whereas before about 300 per day, costing about 9d. each were required.

3. Quality of patch is uniform and so improved by more than 50 per cent.

4. Human variables that cause results in hand-ramming linings are virtually eliminated.

5. Some improvement in metallurgical control in cupola operation is attained.

6. Overall costs of relinings have been reduced by more than 50 per cent.

WARE FORMING WITH RAM PROCESS

Ware forming by the ram process has been adopted by the Shenango Pottery Co., New Castle, Pa., for the production of a large variety of restaurant and hotel china ware, ranging from mustard covers to 10 in. rolled-edge plates. After over a year of operation, Shenango has found the

process offers considerable advantages over jiggering and casting, for many types of ware.

The process itself, although in use in a number of plants, is for the most part, unknown to many potters. It is essentially the forming of ceramic objects from a plastic body by pressing in hard, gypsum-cement dies, and as such is intermediate between jiggering and dry pressing. Probably foremost among its many advantages is its adaptability on production of non-circular pieces of non-uniform cross-section.

Ram Competitive with Casting

Because of these features of the ram process which allow it to form ware previously made only by casting, Shenango use the process extensively for such items as mustard covers, celery boats, bakers and oval plates. In production of such items, savings with the process over former casting methods have frequently amounted to more than 50 per cent. Moreover, there is a saving in the floor space required for the ram method.

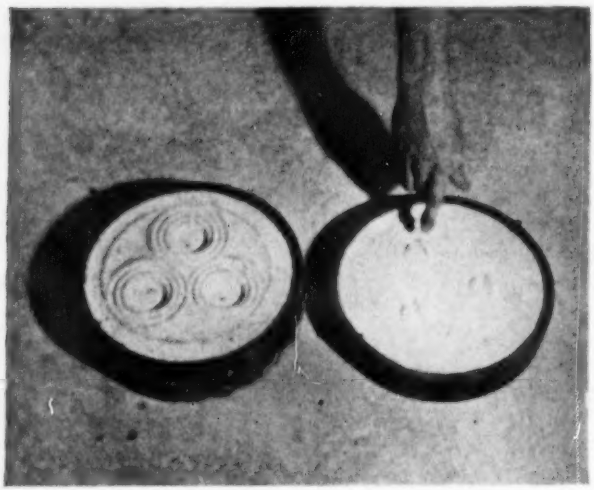
The ram process started first as an idea in the mind of A. R. Blackburn, at present vice-president in the Ram Inc. organisation. It was further developed jointly with Richard Steele, who now controls the research department in the same company.

Briefly, the method is that of forming ceramic objects between two dies. Novel features worked out by Ram permit instantaneous release of the formed object, so that with a single set of dies, rapid production competitive with jiggering for some objects is possible. Ram pressing of most whiteware pieces requires that a batt similar to that used in jiggering first be formed.

Following spreading, the "pancake" thus formed is laid on the lower die by the operator, the press started, and the piece formed. This operation is practically instantaneous as in many similar ceramic pressing processes.

The moisture contained in the body being pressed is removed from the piece by pressure actually being squeezed into the dies. An important feature of ram made possible by the squeezing action is that the pieces can be produced in any condition from leather hard, where drying shrinkage is virtually zero, to a moist condition where the pieces will barely hold shape, all at the discretion of the operator, depending on what his experience shows to be best for the items being produced.

The process makes use of compressed air to facilitate release of the piece from the dies. Normally the operator will allow the piece to remain suspended from the upper die as the dies part, following the pressing, and then will release the suspended ware



Dies used for ware forming by the Ram process

into his hands, or as practised at Shenango, on to a plaster "flag." On some items, however, the operator may prefer to lift the ware from the lower die and may easily do so by letting the upper die release at the time the dies part.

Water squeezed into the dies during pressing is removed from them by vacuum supplemented, at intervals, by compressed air purging of the dies. In purging, the vacuum is momentarily shut off and compressed air is applied for a short period. Water then bubbles to the surface of the dies and is sponged off.

At Shenango, a shelf dryer adjacent to the pressing area receives the flagged ware as it is removed from the press.

Quality Improved

Not only does the pottery find production savings in the process but reports that, through its use, ram-produced items in Shenango's line of vitrified ware are materially stronger. The additional strength, the pottery's mechanical research department reports, is due to the practically strain-free condition of the pressed ware. Warpage, both in drying and firing, is minimised because of this freedom from internal strains, and a higher percentage of first-quality ware is obtained.

Production Figures and Plaster Dies

The importance of the plaster dies in the ram method is manifold. On small ware, in particular, the dies influence the production rate tremendously. This is due to the fact that two, three or more pieces can be pressed simultaneously with a multiple die unit. Use is made of a triplicate die for mustard covers and similar ware, thus raising the production rates for such items.

Die life is, of course, an important factor in the ram process, determining die "use" cost. The adaptation of "Ceramacal," a hard gypsum cement, for the dies has resulted in longer life with, consequently, lower "use" cost. Also, the improved dies give production runs up to 2,000 or 3,000 pieces, cutting the time lost due to die changes to an insignificant amount. Further improvement in die life is expected as die-making technique improves.

Definite advantages are claimed in handling, storage and absence of damage due to rough handling, as compared to casting or jiggering moulds. The storage problem is practically eliminated since only two or possibly three sets of dies are needed for each item being ram pressed; nicks and other surface defects are extremely few since the single die set can be stored and handled individually with proper care.

A 4 ton press is used for very small items such as teapot covers, butter dishes, mustard covers and similar objects up to approximately 4 in. in diameter. Many of these items are also made in multiple dies forming two, three or more pieces with each pressing, on a larger, 8 ton hydraulic press. This second press is used for a wide variety of slightly larger ware including celery boats, ash trays, cereal bowls and baking dishes.

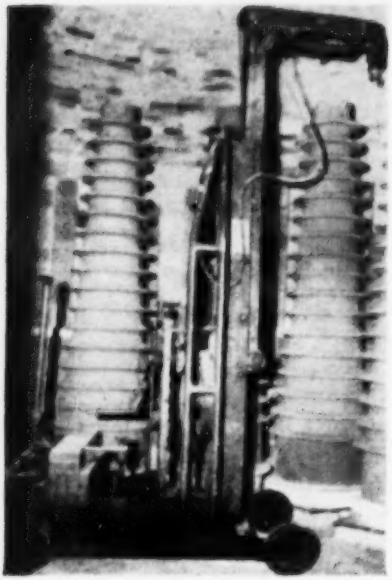
Rolled-edge, 10 in. plates are ram pressed on a 100 ton hydraulic press devoted almost exclusively to their production. Shenango has found that one man working on the Ram press can produce over two-thirds as many of the plates per day as three men normally make by conventional methods.

"THE LATEST IN DINNERWARE, MY DEAR!"

From the pages of an American trade journal a most provocative suggestion caught our eye. We should like to hand it on as food for thought to our more progressive readers. The contributor in question ventures the remark that it was unfortunate that dinnerware alone, of all products, should be not only a lifetime investment, but one handed down from generation to generation. He suggests that fashion and its resultant style cycles could bring unbelievable sales to the industry.

"People keep dinnerware too long . . . and there is almost nothing else today sold on the good old lifetime purchase basis. Clothes, cars and even furniture are 'style depreciated.'

"The pottery industry, facing the prospect of yearly production increases, will be forced to devise new ways to sell its rising output, and the creation of style-obsolescence is suggested as the answer. Why not



Hoist for placing heavy porcelain bushings in periodic-type kiln

develop style consciousness to such a degree that dinnerware will have to be changed every two or three years if the user is to be in the fashion."

The originator of this somewhat revolutionary idea, suggests everyone will gain by its inception; the customer, because families will have bright, interesting and stimulating new dinnerware giving them the same glow of pleasure as would a new car or hat, and the dealer, in as much as he would have a brand new promotion plan, with a new line every two or three years, and could thus put on aggressive advertising campaigns to sell his ware as he had never sold it before. For the manufacturer, it would mean a more rapid turnover and increased production. He would not have to carry stocks of a design and pattern in the forms of moulds, etc. A pattern would be taken off the market after a period of 2-5 years years, just as are cars, and replacement parts guaranteed for only a short time.

We, ourselves, are not too sure of the advisability of such a measure, but feel it is something which readers may like to discuss among themselves. The question is, is it workable, and is it worth working for?

A NOVEL HOIST

A new machine for placing heavy porcelain bushings in a periodic-type kiln has minimised losses and decreased total manual labour by 25 per cent. Where before, six men placed a 600 lb. section with difficulty, only three men are now required and it is expected that the original purchase price of the hoist will be saved within the first 12 months of operation.

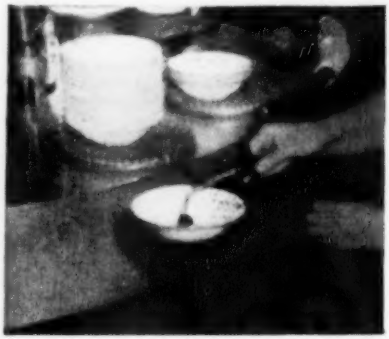
Manually operated, the hoist is mounted on a hand truck, and carries a short boom capable of being raised or lowered, lengthened or shortened, and swung 90 degrees to the right or left of centre.

Gripping such heavy unfired clay pieces so they can be lifted without damage is accomplished by lowering into the body an airtight, nylon-covered bag attached to a metal cylinder suspended on the hoist. The bag is inflated, taking up the space inside the body and giving a firm grip to hoist the piece.

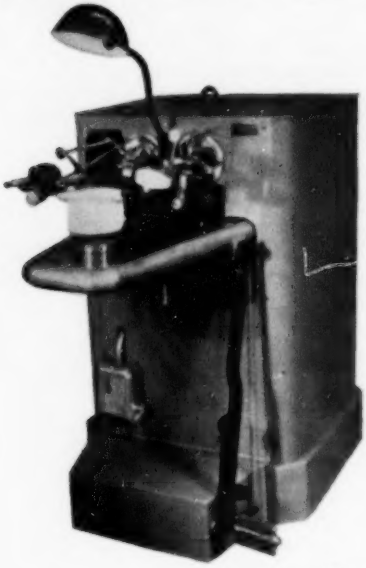
One man operates the machine while the other two guide the second section into place.

SIMPLE DEVICE AVOIDS COLOUR SMEARING

A marked reduction in rejects and re-working operations made necessary by smeared decorations, has been effected by the introduction of tools bearing rubber suction cups for handling ware at the works of the American Homer Laghlin China Co.



Rubber suction tool for handling ware reduces rejects



GOLD EDGE LINES

THE "RYCKMAN" GOLD EDGE LINING MACHINE PRODUCES GOLD EDGE LINE OR STIPPLE ON CUPS, SAUCERS, PLATES, ETC. UNSKILLED FEMALE LABOUR MORE THAN DOUBLES THE USUAL OUTPUT WITH SUPERIOR RESULTS AND A CONSIDERABLE ECONOMY IN GOLD CONSUMPTION.

Manufactured in England by

F. MALKIN & CO. LTD., LONGTON, STOKE-ON-TRENT

TELEPHONE: LONGTON 3871

Weighing only a few ounces, the tools are manually operated by the decorators. They are attached by being pressed lightly against the centre of the piece and will hold it until a release is touched by the operator.

The ware being held at the centre rather than at the edge, as is the case when it is being lifted by hand, marking or smearing of rim lines is virtually eliminated. At Homer Laghlin the principal use of the vacuum cups is to remove ware from lining machines.

COMBINED METHODS SPEED DE-ENAMELLING

While virtually every enamelling plant uses either the universally practiced methods of caustic bath or sand or shot blast to clean porcelain enamel from the base metal, few use the two in combination. At its Hamilton cooker plant the Estate Heatrola Division of Noma Electric Corp., employs the combination of a hot caustic bath followed by sand blasting with the result that de-enamelling is completed in as little as 2½ hours.

At this plant, the shapes to be cleaned are immersed in a gas-heated caustic bath for 2 to 3 hours, depending upon the age of the caustic solution. This loosens the porcelain enamel coating and its complete removal by sand blast is then simple. Following the caustic treatment, the metal shapes are washed with a hose, stacked in the sand blast booth, where cleaning is completed. In some cases, this method of pretreatment with caustic allows the air pressure of the sand blast to be reduced to approximately 55 p.s.i., thereby making possible the sand blast cleaning of thin gauge metal without danger of distortion.

SCRAP RETURNS TO BLUNGERS BY BELT

In conjunction with its automatic jiggers, etc., the Homer Laghlin China Co., uses belt conveyors to transport wet clay scrap to the chutes and blungers for re-processing. The longest conveyor of this type now in use in the company's plant moves the wet body approximately 40 ft.

To do the job of carrying the wet scrap, the firm selected a special smooth, waterproof belt, particularly suited for the job since its water-repellant feature allows it to transport the water which, of course, accompanies the scrap; and its smooth surface lessens the tendency for clay to adhere.

To ensure the complete collection of clay and water, a steel slider trough was designed and built by the company to support the belt. The bottom of this trough is in the shape of a circular arc and catches any overflow from the belt.

Running over 6 in. diameter pulleys, the belt is supported during its return by standard 2 in. rollers. The short radius of the head pulley and the belt's smooth surface makes it practically self-cleaning, but a simple wiper is installed under the pulley to complete cleaning. The wiper does not touch the belt, but is set to clear it by a fraction of an inch, causing no wear.

(Acknowledgments to *Iron Age* and *Ceramic Industry*, U.S.A.)

Mechanical Handling

FROM Lansing Bagnall, of Basingstoke, we have information of their latest aids to mechanical handling, and of particular interest is the pedestrian-controlled electric fork-lift truck, the first of its type produced in this country, intended for all types of loading and unloading operations and handling and stacking materials on pallets, with particular application to warehouses, stores, workshops, etc., where limited floor space necessitates narrow gangways.

Models are available of 12 cwt., 15 cwt. and 1 ton capacity, with either an electro-hydraulic-operated lift of 5 ft. 8 in. or a telescopic lift of 10 ft. 11 in. The overall height of the truck is only 83 in. so that it can pass through any normal doorway.

The latest addition to the range is the electric tractor, which can also be pedestrian controlled, and is designed as a towing type unit suitable for operation in the most confined conditions. Fitted with an automatic-type coupling, and used in conjunction with the castor wheel-type trailer, it finds numerous applications in industry.

Further new units of pallet and stillage trucks include an electrically-

The Lansing Bagnall electric tractor. A towing type unit, for operation in the most confined spaces

Electrically operated, pedestrian controlled, fork-lift truck, by Lansing Bagnall

operated model for handling paper reels, and another version for handling tin plate. The company have also produced a portable bridge plate, to operate in conjunction with railway wagons or road transport. This latter device will allow pedestrian-controlled electric trucks to enter railway wagons, and has the added advantage that the same truck can then pick up the bridge plate and move together to the next job.

Trucks and Tractors

In addition to the above, Lansing Bagnall remind us of their existing range which includes the Model "D", 15 to 20 cwt. capacity platform trucks, with either electric or petrol drive, and their range of petrol-driven model "A" tractors which, with the various engine sizes, give towing capacities of from 25 to 35 tons. A shunting model is also available and in accordance with engine size will shunt loads, on level rails, from 50 to 100 tons.

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Porous Ceramic Media

Their Properties and Application

Based on technical data kindly supplied by Doulton & Co. Ltd., London, S.E.1

IN all processes involving filtration, diffusion or the use of porous electrolytic diaphragms, the pore size and permeability of the porous medium are of utmost importance to the user with regard to the efficient operation of his plant. Upon the pore size depend the clarity of the filtrate in filtration, the intimacy of mixing and evenness of distribution in diffusion, and the efficient separation of the various constituents with maximum conductivity in electrolytic processes. For a given pore size, the porous medium must, in general, have the greatest possible permeability—its resistance to fluid flow in filtration and diffusion, and its resistance to the passage of current in electrolytic processes must be as low as possible.

With these requirements in mind, an intensive study of the various methods of measuring these two fundamental properties have been made and methods of testing developed which ensure consistency of the finished products and which have made possible improvements in manufacturing technique.

Pore Size

Measured maximum pore size is defined as the diameter, expressed in microns (1μ = 0·001 mm.), of the bore of a glass capillary tube which is circular in cross section, and has the same critical pressure as the measured pore. By critical pressure is meant that required to force through the capillary (initially filled with a suitable fluid) a second fluid immiscible with the first.

Determination of measured maximum pore size is rapid and sensitive

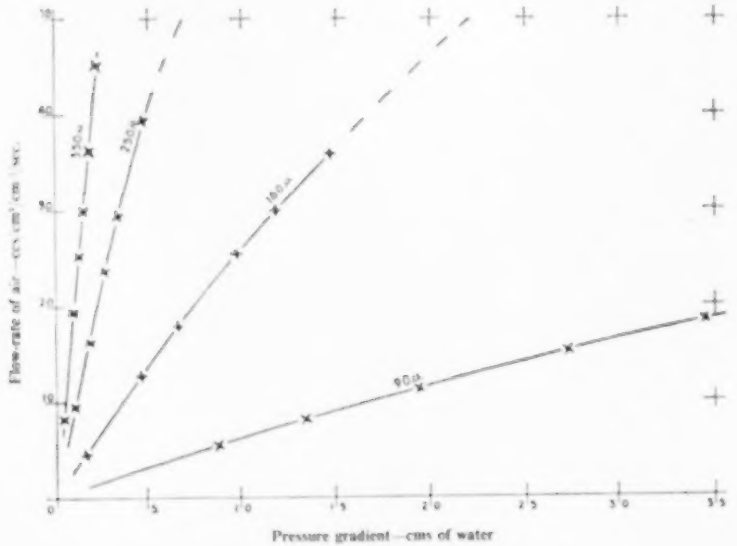

Fig. 1. Flow of clean air through dry media

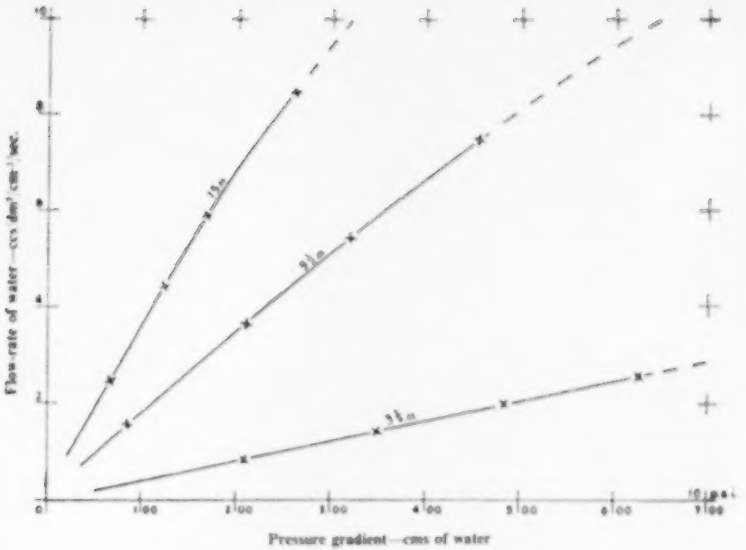

Fig. 2. Flow of clean water through kieselguhr media

and can be applied to products, prior to despatch to customers, for the detection of faults.

The absolute permeability of a porous medium is defined as the volume in cc. of a fluid of unit viscosity which will pass in one second through an area of 1 sq. cm. of the medium, when its thickness is 1 cm. and the pressure difference between its faces is 1 dyne per sq. cm.

The technique of measurement has been found to give a very close agreement in the values of the absolute permeability, using fluids as widely different as air and water.

Practical Aspects

Measured maximum pore size is easy to determine and tests may be made on a hundred or more pieces per hour to ensure that they all fall within the required limits. Measurement of absolute permeability is, on the other hand, a lengthy procedure and can only be applied to a proportion of the articles produced.

There is, however, a relationship between these two fundamental properties such that, by ensuring adequate control in production and by making tests for measured maximum pore size, one may calculate a figure of absolute permeability which corresponds very closely to that derived from flow measurements.

Figs. 1 and 2 give typical flow curves plotted during the determination of absolute permeability.

It is for a number of reasons impracticable to classify the various grades by the size of particle retained. Experience shows, however, that these media will, in general, retain solid particles down to a size approximately one third that of the measured maximum pore size. In practice it frequently happens that still smaller particles are retained by the filter medium, due to effects such as bridging and the retentivity of the entrapped solids.

A general law, covering the decline in flow-rate or increased pressure drop resulting from the resistance of solids retained during filtration, cannot be evolved. At high rates of flow the effects of turbulence become considerable and the relationship between flow-rate and pressure drop is no longer linear. Further, the delivery rates from high capacity filter elements may be considerably influenced by restrictions elsewhere in the system, which have the effect of reducing the pressure available at the filter surface.

Porous ceramic media are widely used as aerators or diffusers, especially in the diffusion of gases into liquids, and Fig. 3 shows typical flow curves for the passage of air through dry media, and through the same media when immersed in water.

Fig. 4 illustrates the effect of passing compressed air into two interconnected kieselguhr candles. The candles are normal and fast grades and the difference in their permeabilities is quite apparent.

Use in Electrolytic Processes

Yet another interesting aspect of porous ceramic media is their use as diaphragms in many electrolytic processes. These diaphragms are made from special types of unglazed porcelain and offer a very low electrical resistance, while retaining their mechanical strength and uniformity of structure under all conditions. Their small, carefully controlled pore size with maximum possible pore density, their resistance to acids, and their very thin but strong walls are important features.

Porous ceramic slabs and tiles are used as drying plates—large size slabs in the preparation of blue-print paper, and small 1 in. squares, broken from a larger "chocolate block" tile, for crystal drying. Saucers made from porous ceramic bodies are used for seed germination. Special types are used in absorption towers and reactors, or to control moisture content and to introduce germ-destroying vapour into the atmosphere.

The chemical resistance and inertness of ceramic filters make their use a great economy where corrosive liquors or gases are employed, and their mechanical strength enables them to be used under high pressures and permits normal handling without danger of breaking or chipping, while their resistance to high temperatures makes possible filtration or diffusion processes under conditions which are prohibitive with other types of media. Thorough cleaning can be assured by use of hot acids or steam, or by boiling or baking where necessary.

Ceramic media are available in various shapes, such as square, rectangular and circular tiles—plain, grooved or ridged; cylinders—both ends open or closed at one end, flanged or with spigot and socket; plain discs or discs with centre holes; pots and tanks, or blocks and solid

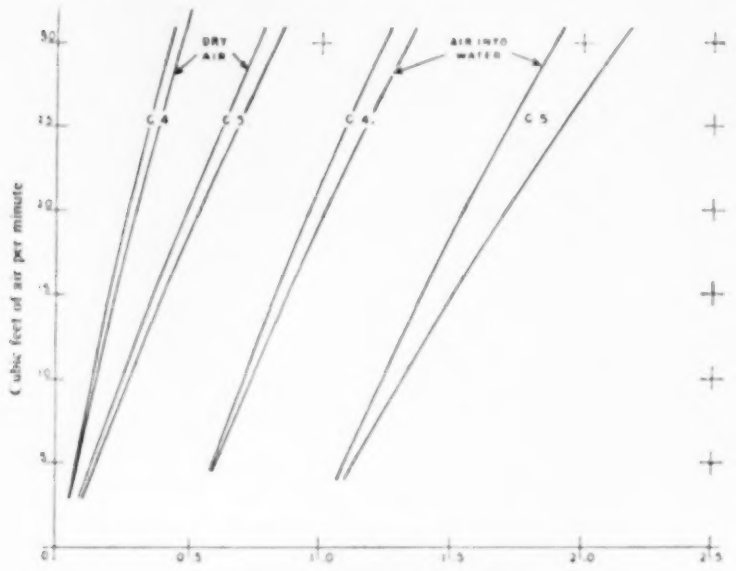

Fig. 3. Air flow through dry media, and through media immersed in water

rods; and many other designs made specially to order. They can be designed to fit in vats, vacuum filter units and similar apparatus. They are supplied ready for immediate use in various types of unit, or may be supplied for fitting into existing plant. Certain types may be cut, ground or sawn to specific measurements.

Filtration, considered simply as the separation of solids from liquids, is employed by nature in countless instances and is perhaps one of the oldest physical processes known to man.

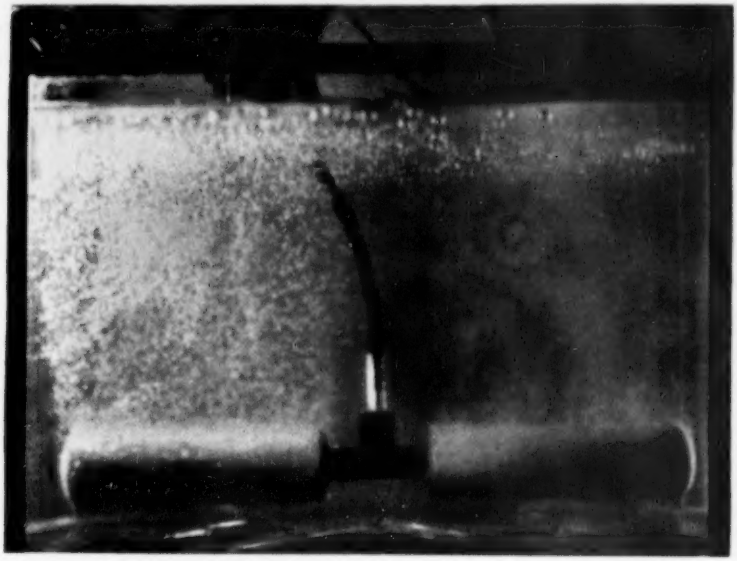

Fig. 4. The passage of air into water through two interconnected kieselguhr candles of different grades. Grade KF on left and grade KN on right. Pressure of air in supply line 11 lb. per sq. in. (570 mm. mercury)

Today filtration has become one of the most widely employed processes in the treatment of water for domestic purposes, and in large scale modern industry. Its purpose may be the clarification of a liquid, the collection of a precipitate, or both. It may involve the separation of solid or liquid from gases, or of solid or liquid from liquids. Porous ceramics have already proved invaluable in filtration in many different industries and are, in addition, extensively used as aerators or diffusers, and as electrolytic diaphragms. To meet the growing demand, three principal types of porous ceramic media have been developed and details of the various grades, together with pore sizes and flow characteristics are outlined as follows.

Industrial Porous Ceramic Media

These materials are made from carefully graded granules, bonded together, with a minimum of bonding materials by firing at high temperatures.

The granules of the coarser grades are prepared by a special process designed to give uniformity in grain size and shape, with consequent increased permeability. The two photomicrographs show (Fig. 5) a typical sample of granules which will be used in forming a medium grade porous plate and (Fig. 6) the texture at the surface of one of these plates. In the manufacture of the finer grades, quartz (sand) grains, specially selected for purity and shape, are carefully graded before bonding together into the required form.

These media cover a range of pore sizes from approximately 750 microns down to 20 microns and their permeabilities are, in general, so great that the flow rates depend very largely upon the individual characteristics and

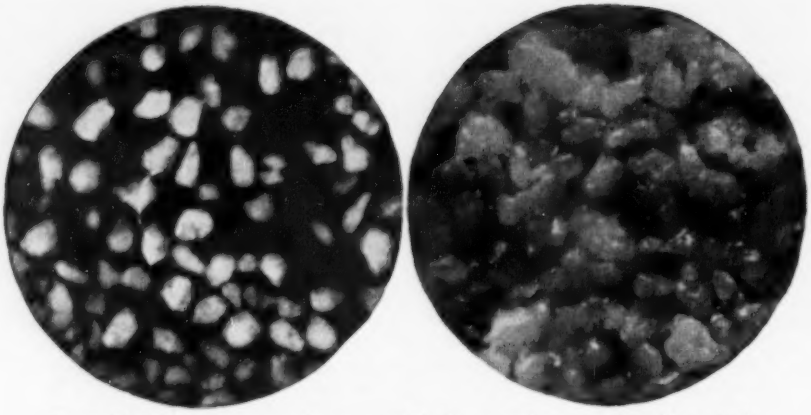

Fig. 5 (left) Ceramic granules as used in the manufacture of medium grade porous media. Magnification 36x. Fig. 6 (right) Photomicrograph of a portion of the surface of a medium grade porous plate made from granules in Fig. 5. Magnification 48x

in particular upon the restrictive influences of the flow system in which they are used. Consequently, measurements made on individual samples may be used as a guide to the most suitable grade for any particular application, but the need may arise for pilot-plant tests to determine the size of unit to be employed.

Kieselguhr Media

Diatoms, found both in fresh and in salt water, are perhaps more widely distributed than any others of the minute organisms (infusoria) inhabiting water. The diatom has a siliceous skeleton which falls, when the living organism dies, to the bed of the lake or sea and takes its place amongst countless millions of its kind.

These skeletons (or frustules) have long been a source of delight to the microscopist and the accompanying photomicrograph (Fig. 7) captures, in part only, their beauty as seen under the microscope. The specimens are skeletons of living organisms from the Indian Ocean and the slide was chosen for the large variety of shapes and sizes that it represents. Today, kieselguhr (or diatomaceous earth), deposited in prehistoric times and raised by geological upheaval above sea-level, has many applications and is of utmost importance in filtration.

Kieselguhr filter media range in pore size from approximately 25 microns down to approximately 2 microns. They are used throughout the world for purifying drinking water. New applications for these materials (as diffusers as well as filter media) are constantly coming to light and their usefulness in pharmacy and allied industries for the production of sterile liquids has long been recognised.

Porous Porcelain

Concurrently with the bacteriological researches of Professor Louis Pasteur, the discovery was made that it is possible, by filtration through a porous porcelain tube or candle, to produce a sterile solution from one heavily contaminated with bacteria.

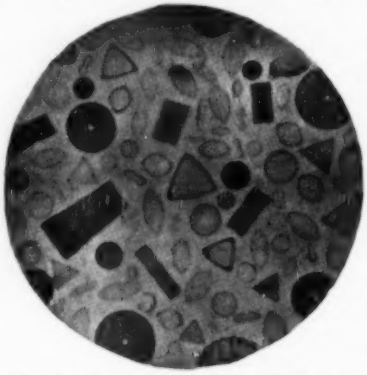

Fig. 7. Photomicrograph of diatoms from the Indian Ocean, siliceous skeletons of the type used in the manufacture of kieselguhr media. Magnification 60x

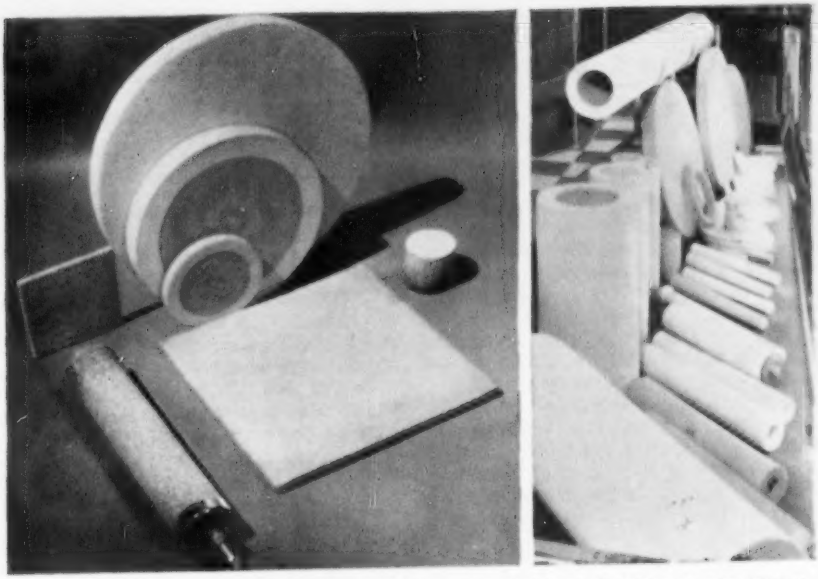

Fig. 8. Circular plates for vacuum filter units (with and without non-porous surround) and other types of porous ceramic media, including a standard 10 in. by 2 in. (250 mm. × 50 mm.) filter candle with metal fitting

Today, these candles are used throughout the world for the sterilisaton of drinking water for domestic purposes, as bacteriological filters in hospitals, and in the production of sterile solutions in pharmacy.

This is not, however, the only application of porous porcelain, for it is widely used in electrolytic processes, and the coarser grades are becoming increasingly popular as aerators (or diffusers) and for the filtration of liquids where the solid or liquid matter to be removed is finely divided. In many instances the clarity of the filtrate more than justifies the comparatively slow flow rates which are experienced.

STONEWARE PACKAGING IN DEMAND

USE of stoneware containers for export packaging—and the creation of some very attractive examples of "keepsake" type ware—is a current activity in Scotland. One leading stoneware firm is producing very fine preserve jars for Canada and the U.S.A., decorated by copperplate print.

An even more interesting move is the request by a Scottish packer for stoneware containers of ½ lb. and ¼ lb. size in twelve authentic tartans. These jars are intended to carry a Scottish preserve to the North American market where tartan is currently in vogue. Tartan would also indicate the Scottish origin of the preserve, while a tartan-decorated stoneware container would be an excellent goodwill builder. Policy will be to print the tartan directly on the stoneware jar, thus giving a permanent decorated container of a unique type.

POTTERY EXPORTS

POTTERY exports in June amounted in value to £1,891,745, compared with £1,576,424 in June last year and £1,705,552 in June, 1948. In the first six months of this year their value was £11,036,766, compared with £10,505,678 in the first half of 1949 and £9,634,160 in the first half of 1948. In volume, last month's exports were 550,402 cwt., compared with 417,790 cwt. in June, 1949, and 467,882 cwt. in June, 1948. For the half-year period they were 2,971,784 cwt. this year, 2,753,429 cwt. last year and 2,346,441 cwt. in 1948.

Burning Face Brick in a Direct Fired Tunnel Kiln

THE Los Angeles Brick Co.'s Harrop tunnel kiln described in this article is normally used to fire quality firebrick, acid-resisting building brick and a large variety of custom face brick.

The firing zone temperatures of this kiln can be varied over a wide range and can be very accurately controlled. The speed with which the cars travel through the kilns can likewise be varied. The time and temperature control offered by a kiln of this type makes it adaptable for manufacturing a variety of high quality ceramic products.

Kiln Data

This 205 ft. tunnel kiln has a 41 ft. 5 in. firing zone, with a provision for air cooling car wheels and car running gear. The air for cooling the car running gear and for maintaining kiln pressure and proper heat flow is supplied from a 7½ h.p. Sirroco squirrel cage type blower located near the discharge end of the kiln. A second 7½ h.p. blower is used to supply combustion air for the combination oil or gas burners. A third 7½ h.p. blower located near the loading end of the kiln produces an induced draught discharging flue products into the brick stack.

A slight positive pressure is maintained in the centre of the firing zone with a negative pressure close to the floor level, the air flow being from the discharge end towards the loading end where the products of combustion are pulled downward and exhausted near the floor level.

An oil-actuated hydraulic ram applies a steady driving force at the base of the rear car and is transmitted from one car to the next.

The cars are designed to butt against one another, forming a relatively tight seal at the top of the car bed. This seal is achieved by means of a lip which extends over the base of one car and seals into a recess in the base of the next car. The car tracks and running gear are isolated from the heating zone by means of a sand seal at the base and sides of each car.

Cold air from the No. 3 blower is discharged into the discharge end of the kiln. This air travels towards the loading end of the kiln. A portion of air from this blower is forced under the cars in order to keep the temperature of the running gear below 400° F.

Burner Equipment

Twelve 2 in. Shurs combination oil or gas combination nozzle mix burners are incorporated, six burners on either side of firing zone, slightly staggered. Burners are on approximately 6 ft. centres. Combustion air is supplied from a 7½ h.p., 16 oz. Spencer 950 c.f.m. blower. The air manifold pressure can be varied from 16 in. to 21 in. w.g. The gas burner manifold pressure likewise can be varied from 16 in. to 21 in. w.g.

Control Data

A seventeen-position heat zone indicator is located on the operator's control panel approximately 6 ft. from the side of the kiln, near the discharge end of the firing zone. The kiln operator can check the thermocouple reading of each of the seventeen thermocouples from this central point. His control board shows the load and position of each car in the kiln.

Operation

The temperature in the firing zone of the Harrop kiln is indicated on thermocouples 5, 6, 7 and 8, which are located in the top of the kiln arch and on thermocouples 14, 15, 16 and 17, which are located in the curve of the arch.

A temperature guide sheet is prepared by the chief chemist for each

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type of brick. This guide indicates the temperatures which he wishes maintained at the eight firing zone thermocouple location and also indicates the car schedule or time cycle for that particular product.

A seven car per 24 hr. schedule represents a 78 hr. and 58 min. firing cycle for each car.

The fuel input on each of the twelve Shurs nozzle mix burners is adjusted to maintain the indicated guide temperatures at all times.

Large Norman ruffle face brick were being fired at the time the following data were collected:

Finished dimensions: 3½ in. by 11½ in. by 2⅝ in. Weight (shrinkage approximately 1 in. per lineal foot—25 per cent. by weight).

Loading: 1,016 bricks per car—23 cars per kiln load—23,368 bricks per kiln.

Production: 7 cars per 24 hours—7,112 bricks per 24 hr. (one 1,016-brick car every 3 hr. and 26 min.).

Gas pressure at burner manifold: 21 in. w.g. air pressure at burner manifold—17 in. w.g.

Average gas input—116,843·4 c. ft. per day, 4,868·4 c. ft. per hr., 16,429 c. ft. per 1,000 finished bricks.

Results

This kiln has operated almost continuously 24 hours a day since 1937, requiring but a minimum of maintenance.

The flexibility of this kiln makes it possible to control the time temperature cycle accurately, readily duplicating previous firing conditions.

A Potentiometer Recorder.—We have received from Elliott Brothers (London) Ltd., Century Works, Lewisham, London, S.E.13, two interesting booklets; one describes the Potentiometer Recorder—publication No. G.126A—and the other the Elliottrol Trimode Controller—publication No. G.127A. The former operates on the Wheatstone principle and may be used for thermocouples and thermopiles for temperature movement, and when used as a DC Wheatstone bridge it can be used with a DC resistance thermometer. The latter instrument has been developed to meet the tendency towards continuous production processes which demand automatic control.

Fibreglass

by

A. M. ROBERTSON

A JOINT meeting with the London and South - Eastern Counties Section of the Royal Institute of Chemistry was held some time ago at the London School of Hygiene and Tropical Medicine, London. Dr. A. C. Monkhouse (chairman of the London section of the Society) was in the chair and he was supported by the chairman and hon. secretary of the London and South-Eastern Counties Section of the Royal Institute of Chemistry.

At this meeting, **Mr. A. M. Robertson,** gave a lecture on "Fibreglass", during which he said that contrary to the usual view, fibres drawn from glass were no new discovery, being probably known to the ancients and certainly recorded as used by the Venetians for their decorative glassware. On the industrial side a British Patent for the use of glass fibres as lampwicks is dated 1822. The lecturer then passed on to the more recent history of the industry and described the several processes in use.

For textile purposes glass is first formed into marbles which are readily fed automatically into the small melting tank. In the continuous system of glass-wool production the raw materials are fed directly into one end of the glass-melting tank while fibres are drawn off at the outgoing end.

Three basic processes of fibre forming are used, namely mechanical drawing for making yarns, blast drawing, a very high output process for wool, and centrifugal formation of wool. The lecturer described these methods in detail and illustrated the stages with a long series of slides.

Characteristics

(1) *Heat resistance.*—Tape can be heated safely up to 700° C. and is thus suitable for electrical purposes where the limit is set by impregnating varnishes at around 300° C. An inherently fireproof cloth can also be made.

(2) *Non - hygroscopicity.*—Moisture pick-up is very low, while a glass fabric will dry out more rapidly than a cotton one.

(3) *Resistance to weathering.*—This depends on the type of glass so that scrupulous care is necessary in the formulation of fibrous glass.

(4) *Electrical properties.* — Low-alkali glass has a high softening point, high volume resistivity, excellent dielectric strength and low power factor.

(5) *Tensile strength.*—Yarns, cords, tapes and cloths have strengths well beyond those of orthodox textile materials.

(6) *Thermal conductivity.*—There is a range of conductivity according to the closeness of packing. When lying loosely an excellent heat insulator is provided.

(7) *Good space factor.* — High strength and ease of handling permit thin coverings to be used.

Applications

A multitude of applications derive from the characteristics listed above. The main outlets are in heat, electrical and sound insulation, in filtration of air and solutions, in making fireproof fabrics, and in reinforcing laminates, but miscellaneous materials of growing importance should also be mentioned. These include staple tissue impregnated with bitumen which has many uses in pipe wrapping and weather - proofing; battery retainer mats which enhance life; and an important medical application, a glass rayon bandage for fractures, which is dipped in acetone and applied. When it dries off it forms a rigid, light, and strong cast far superior to the "plaster of paris" type.

The lecturer concluded by saying that the industry no longer supplies a

"substitute" material, but a material which is able to compete on its own merits in many industrial fields.

Discussion

The Chairman said he had always been intrigued about the question of annealing fibreglass and why there was not a tendency for it to break. There was also the question of dust. He remembered that when working with glass wool in the old days there was a good deal of worry on this score. Further, he asked if any protection had to be provided against rats and mice. Could animals eat through it without damage to themselves? **Mr. Robertson** replied that there was no need to take any special temperature precautions in the room in which the fibres were being produced in order to prevent annealing. It was almost a toughened glass. It was found that a dry warm atmosphere gave a higher twisting and doubling efficiency than would be obtained in a cold humid atmosphere.

In regard to dust, he had been concerned with the production of glass fibres since 1929. When a person first went into a fibreglass works he suffered from skin irritation but after a few weeks he became acclimatised and after three or four weeks he could literally bathe in the material and not get redness of the skin. Neither the Home Office nor anyone else asked for special precautions to be taken, although there might have to be special precautions in batch mixing. The dust could be inhaled with impunity because there was no free silica in it. It was a silicate and that involved no risk of silicosis.

Replying to the point with regard to rats and mice, he said that probably a determined rat could bore through glass wool but he doubted whether the rat would care very much to do it; he certainly could not make a living out of it!

Mr. M. D. Beech said he had tried fibreglass in a filter press but his experience with it indicated that its mechanical strength was not sufficient for the purpose. **Mr. Robertson** replied that quite a number of filtration jobs had been carried out with fibreglass but most of the filter cloths were made from staple fibre. The failure usually took place at pressure points in the filter, and it was necessary to take special precautions at these points and around holes. Glass was more sensitive to abrasion and with glass in cloth form, which was being continuously crushed, there was certain to be breakdown. To overcome the trouble the usual procedure was to treat the pressure points and flexing points with rubber latex or one of the synthetic latexes.

Mr. H. K. Cameron, commenting on the fact that whereas with the early dress made of fibreglass the wearer could not sit down, it was possible to sit down in the latest type of dress made from this material, asked what fibre diameter made a material which could be safely handled. He also asked whether there was erosion or wearing of the orifices of the platinum crucible: how long did it last? **Mr. Robertson** replied that fibre diameter was the whole secret. The early glass dress was made with fibres having a diameter of 0·001 in. but the later dress had fibres of a diameter of one-fifth of a thousandth of an inch. Just where the borderline came it was difficult to say but below three-tenths of a thousandth flexibility was almost perfect. As to wear on the platinum crucible, he was in the habit of buying platinum in sheet form and welding his own crucibles. The orifice diameter was of the order of 1/32 in. and fibres having a diameter of a five-thousandth of an inch were drawn. As the orifice became enlarged it was possible to adjust the drawing speed and still maintain the original fibre diameter. After about six months the crucible was fitted with a new set of dies and this gave another six months life to it. At the end of that time, the crucible was scrapped and sent back for recovery.

Mr. J. R. Ronca asked whether glass cloth had been used for cinematograph screens. One would rather expect to get the cat's-eye effect and presumably the diameter of the fibre would be rather important. **Mr. Robertson** said that quite a lot of work had been done in connection with the use of glass cloth for cinematograph screens and he believed it would eventually replace the present type of screen very successfully.

Mr. D. M. Freeland enquired whether glass fibre cloth had been used as webbing for conveyor belts dealing with foodstuffs? **Mr. Robertson** replied that he did not know of any such case. There were conveyor belts using fibreglass cloth as the reinforcing medium, but he knew of no case where ordinary glass cloth had been used for conveying food.

Cost

Mr. Freeland then asked for information as to the cost of fibreglass cloth. **Mr. Robertson** said it was possible to obtain glass cloths which were priced at about the same figure as rayon and nylon material. Prices ranged from about 3s. 6d. per yard to £1 per yard according to the weight of the material. It was quite a good commercial proposition.

Mr. F. Brookhouse asked if the author seriously suggested that glass fibre could be used for dresses in a big way. It seemed to him that the wearer would not be able to sit down without risk of damage and, as a dyer, he was scared to think what would happen. Could such dresses be ironed in the usual way? **Mr. Robertson** said that to be perfectly honest, the glass dresses were really sales propaganda. They might be used on the stage in a scene where they had some decorative effect but nobody would recommend them for a dance hall, for example.

Mr. T. McLachlan asked whether glass fibre when used as an insulating material on board ship was subject to settlement as in the case of cork, due to the movement of the ship. **Mr. Robertson** replied that several ships were insulated in this way in 1942. They had been opened up recently and there was no sign of settlement. The results were still being examined and a phamphlet would shortly be in circulation which he thought would settle all doubts on that point.

Mr. Guest enquired whether there had been any trouble with static electricity. He also said there was a use which had not been mentioned, namely in connection with high-vacuum distillation. As far as he knew, two papers only had been published on this subject, and they were both American. It seemed that the results varied according to whether the fibres were placed horizontally or vertically. If they were vertical their behaviour was not very good, but if they were arranged horizontally they behaved more normally. It also appeared that the results were improved if the glass fibre was packed very tightly. Had the author any information on this matter? **Mr. Robertson** replied that it was true there was a slight risk of static electricity when twisting and doubling glass fibres, but it was far less than in the case of nylon and rayon, and no trouble had yet been experienced in this connection. With regard to fractionating columns, the two American papers mentioned were quite well known, and he himself had supplied coarse fibre, five-thousandths and ten-thousandths of an inch, for experimental purposes. As far as he knew, the material appeared to be reasonably successful. The fibres in these towers were arranged more or less horizontally. However, there was no big demand for this material so far and it had only been used experimentally.

Paper-making Possibilities

Mr. S. R. L. Edge remarked that nothing had been said about the paper-making possibilities of fibreglass, but that was a matter in which we in this country were ahead of any other country in the world. Paper had been made utilising up to 80 per cent. glass fibre, but so far it had not been possible to find a buyer for that particular material. There was a buyer, however, for paper containing 50 per cent. of glass fibre for accumulator separators, for which purpose it was used to a large extent. A considerable number of tons of that material had been produced, and a similar quantity of paper containing up to 80 per cent. of glass fibre could be made if anybody wanted it. **Mr. Robertson** replied that he had purposely refrained from discussing the use of glass fibres in paper-making because, at the moment, it was really experimental, although it had reached an advanced experimental stage. As it had been referred to, however, he would say that this glass-base paper had been very successful for separators for accumulators.

Mr. P. H. Fisk asked for informa-

tion with regard to the use of fibreglass coated with bituminous solution for roofing felt. He said that considerable difficulty had been found in obtaining a suitable wetting agent. **Mr. Robertson** replied that quite a lot of experimental work had been done in this connection, but he could give no information on the wetting agent that would make the material adhere to the glass. In the United States a good deal of work had been done and the difficulty mentioned might be tied up with the binder which was put on the fibre to hold it together. A change in the binder might make for better adhesion and better wetting.

Dr. C. W. Herd (chairman, London and South-Eastern Counties Section, Royal Institute of Chemistry), proposing a vote of thanks to Mr. Robertson expressed pleasure at the holding of this joint meeting, especially when there was such an interesting lecture as the one given by Mr. Robertson. It had been most informative, and although he came to the meeting knowing nothing at all about fibreglass, he thought they would all go away knowing very much more about it because of the very clear way in which the lecture had been delivered.

The vote of thanks was cordially given and the meeting closed.

(With acknowledgment, "Chemistry and Industry.")

Oil Burning in the Glass Industry

A JOINT paper was recently presented to the Midland Section of the Society of Glass Technology, by Mr. M. Roddan, of Shell-Mex Ltd., and Mr. D. Sismey, of Sismey and Linforth Ltd., on the above subject. Mr. Roddan opened the proceedings by saying that in the glass industry fuel is one of the main items of production cost, and therefore it is of prime importance that fuel should be used in the most efficient manner practicable. Liquid fuels have certain inherent properties which, if properly exploited, are of great value in a high temperature process such as glass melting but which, on the other hand, can be nullified by careless or faulty application. These factors are high flame temperature and high luminosity, both of which are of great importance in increasing the rate of heat transfer and therefore of production.

The theoretical flame temperature of fuel oil with cold air is higher than that of industrial gases and very much higher than producer gas, the most popular alternative fuel. The figures are:

Fuel Oil ..	2,080° C. or 3,780° F.
Producer Gas	1,600° C. or 2,660° F.

Excess Air

These temperatures can only be approached in practice if the process of combustion is rapid, and is carried out with the minimum of excess air.

The effect of excess air on temperature is shown in Fig. 1. This graph has been prepared primarily to show the percentage of heat in the fuel carried away by the exit gases for various exit temperatures and percentages of excess air, but it will be noted that the 100 per cent. loss line gives the theoretical flame temperature for different percentages of excess air over 15 per cent. The normal method of assessing the excess air in boilers and heating furnaces is by measuring the CO_2 content and this line has been superimposed on the chart for convenience. The CO_2 content of the gases from a glass tank is affected by the batch, and therefore a measurement of oxygen content is the only reliable indication of the excess air present. This is probably the main reason why CO_2 recorders are rarely used on the glass tanks, but are considered essential on a modern boiler plant on which the potential saving by

Two papers presented recently to the Society of Glass Technology—Midland Section—by M. Roddan, M.Inst.Pet., M.Inst.F., and D. Sismey, B.Sc., M.Inst.F.

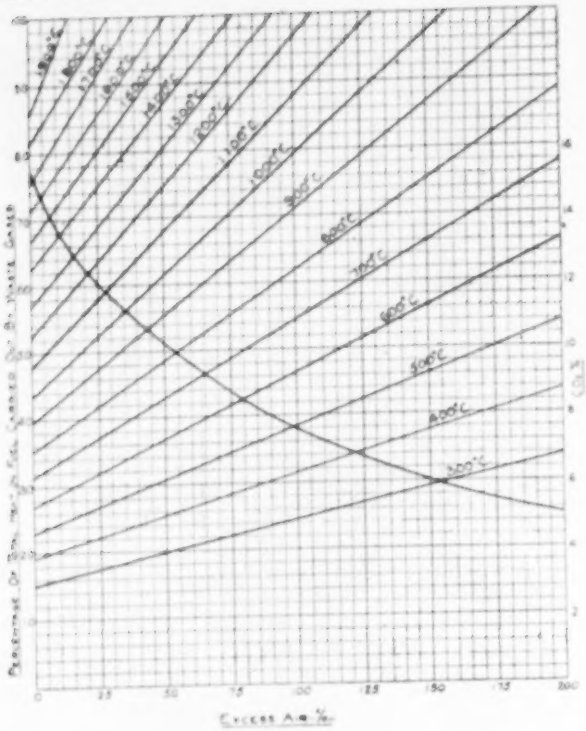

Fig. 1. Chart showing effect of excess air on the amount of heat carried out in waste gases at various temperatures

close control of excess air is very much less than on a glass tank as an example will show:

Neglecting for the moment the effect of preheating the combustion air, and taking the same two conditions of excess air for a boiler plant with exit temperature of 300° C. and a glass tank with exit temperature of 1,300° C. The heat carried away by flue gases on the boiler with 75 per cent. excess air is 22 per cent., and if the excess air is reduced to 15 per cent., the loss is reduced to 16·5 per cent., a difference of 5·5 per cent. On the glass tank at 75 per cent. excess air the loss is 92 per cent., and by reducing the excess air to 15 per cent., the loss is reduced to 65 per cent., a difference of 27 per cent.

This is not a true picture, of course, where an efficient regenerator or recuperator is fitted because with the larger percentage of excess air there is a greater weight of exit gases from which heat can be transferred to the combustion air. The close control of excess air is, however, of the utmost importance in maintaining the thermal efficiency on any high temperature furnace.

It is also clear from the chart that if the excess air is more than 92 per cent., the temperature of 1,300° C. cannot be reached with cold air even theoretically.

Glass melting furnaces practically all use highly preheated air. It should be noted that to attain the high temperature given by fuel oil with 20 per cent. excess of cold air it is necessary to preheat the air and producer gas to about 650° C.

It is well known that at high temperature, radiation is the most important factor in heat transmission in a furnace, and, as according to the Stefan-Boltzmann law, radiation is proportional to the difference between the fourth power of the absolute temperature of the radiating body and the fourth power of the absolute temperature of the receiving body, the importance of high flame temperature is obvious.

In his address to you last month

Dr. Waterton gave some statistics about glass tanks, and if I remember right he said there were about 150 tanks in use in this country, roughly 100 regenerator and 50 recuperator. These tanks varied in size from 3,000 sq. ft. to 50 sq. ft. and while the larger tanks were all fitted with efficient air heaters, some of the smaller ones were mere boxes of bricks with an oil burner stuck in one end.

It is, of course, possible to melt with oil, although not with producer gas, under these conditions, but it is a wasteful and expensive process and when one realises that with efficient waste heat recovery the oil consumption would be halved, it is surprising to learn that such installations still exist. The other advantageous quality of liquid fuel flame is its luminosity which cannot yet be evaluated by calculation, but the importance of this property in high temperature processes is well known and recognised. The glowing particles of carbon in an oil flame cause it to be become opaque and luminous, whereas flames which do not contain such particles tend to be transparent and non-luminous.

Some very useful increase in luminosity of producer gas flame has been obtained by introducing a hydro carbon oil into the gas stream, and a similar effect is obtained if the producer can be transferred close enough to the furnace to permit the carry over of tar with the hot producer gas.

Since the use of oil on open hearth steel melting furnaces became popular in this country a few years ago, much attention has been focussed on luminosity, and some very important research work is now being done on the subject. For more detailed information on temperature and luminosity of oil flames, I would refer you to a paper entitled "Liquid Fuel for High Temperature Processes," by Bailey, Battershill and Bressey, given at the Fuel and Future Conference in October, 1946.

Practical Consideration

There are two main factors involved in producing good combustion conditions, namely atomisation of the oil, and mixing the atomised oil with the combustion air. Atomisation is a function of the oil burner and mixing of the burner and air director combined with furnace design.

Instead of trying to explain what is meant by atomisation of oil, I have brought along a film on the subject. (The film was then shown.)

The atomisation in the picture was produced by high pressure, and is commonly known as mechanical or pressure jet atomisation. This system is almost universally used on large oil-fired boilers as it is the cheapest method of atomising oil, and is very well suited to the relatively low temperature combustion conditions. The combustion air can be introduced evenly round the oil spray through metallic air directors and good mixing conditions can be ensured with very little maintenance over long periods.

In a high temperature furnace, as used for glass melting, conditions are very much more onerous. The air must be introduced through ports made of refractory material which cannot be of complicated shape, and which are liable to fairly rapid deterioration. The burner nose also would require to be water-cooled. Further, in regenerative furnaces the air port becomes the waste gas port on reversal, and it is difficult to design a port which will perform both functions satisfactorily.

Pressure Jet Burners

Pressure jet burners are used on glass tanks in France, and some experience has also been gained with this system in England, but the abovementioned difficulties have been encountered, and in this country high pressure air atomisation is almost universally used on large glass tanks. In this system the oil is atomised by a small quantity of air, usually at pressures of about 20/25 lb. per sq. in. Only some 2½/5 per cent. of the combustion air is used cold for atomisation, and the drop in efficiency, due to this, is offset by better penetrating power and the greatest facility provided for fitting the flame to the shape dictated by furnace requirements.

If high pressure air is not already available in the factory for operating the glass-making machinery the installation and maintenance of compressor plant is an expensive item, and it is worth while considering if the desired results can be more economically attained by using air at what

is usually termed medium pressure—10/12 lb. per sq. in.— produced by a rotary-type compressor, which is cheaper to instal and maintain than the piston type. A higher percentage of the combustion air will be required for atomising, but this will only be of the order of 5/7 per cent. of the total, and the thermal loss, due to introducing this quantity cold, is not very serious. Certainly for the pot-type furnaces this seems to be the best atomising medium when all factors are taken into account.

On pot-type furnaces low pressure air burners are still commonly used, that is, burners using air from a fan at up to 1 lb. per sq. in. This type of burner requires at least 20 per cent. of the combustion air for atomising, and will more generally be found to use around 30 per cent. of the air cold for this purpose. On a conservative estimate a saving of 5 per cent. of fuel should result from changing from low pressure air to medium pressure air on a multi-pot furnace as used in this district, assuming, of course, that the recuperator is of adequate capacity to heat the additional air.

Furnace Design

The other important factor in obtaining correct mixing is furnace design. The ideal arrangement is to introduce the oil co-axially with the air, but as this is often not possible, some compromise must be adopted. In converting cross-fired regenerative tanks from gas- to oil-firing the burners have been applied in practically all positions around the port; end, top, bottom and sides in effecting a compromise between the most desirable burner position and the simplicity of application and operation on the particular furnace construction. In many cases better positioning of the burner could be attained by using water cooling, but this is a complication which is not generally favoured.

The usual method of firing in this country is down through the top of the ports, the burner being aimed down at the surface of the metal about half way across the tank. The incoming air deflects the oil spray and prevents undue impingement. Some American firms, and at least one in this country, have adopted under-port firing, with the burners angled up towards the crown, the flame being deflected downwards by the incoming air. This arrangement on a large tank gives much better access to the burners.

Gable-end firing is commonly used to maintain production during burning out periods on gas-fired tanks, and with careful attention to burner design to ensure that the air from the inner ports gets its proper quota of oil, this arrangement can and has been used on production. On a recuperative tank it is usually easier to arrange the burners in the desired position, and water cooling can be applied, if necessary, without undue complication.

Designed for Oil and Gas

Most of the oil-fired glass melting tanks in this country have either been converted from gas firing, or have been designed and built so that they can be readily converted to gas firing should the economic or supply position warrant it. This being so they cannot be expected to give as good a performance as furnaces specifically designed for liquid fuel.

On open hearth steel melting furnaces which are fired in much the same way as a regenerative glass tank, this has been found to be of the utmost importance, and in some cases reduction in consumption of as much as 25 per cent. has been obtained by changing the port and furnace design to suit the peculiarities of liquid fuel firing.

There is nothing in past experiences to justify making provision for switching over to gas when building an oil-fired furnace; at no time in the past 30 years has the supply of liquid fuel failed, and there are clear indications that there will be plentiful supplies of fuel oil in the future. The new oil refinery programme which has full Government approval will, within the next 2 or 3 years, make available in this country over twice as much fuel oil as is now being used. High temperature processes like glass melting, which can exploit the inherent advantages of oil firing can absorb this additional oil to the benefit of the industries and the country as a whole.

Mr. D. Sismey then gave his more light-hearted talk, as follows:

"You have listened with admirable

and respectful patience to our friend, Mr. Roddan. You have watched his most interesting moving picture show from the best seats, completely exempt from Entertainment-tax, with the same admirable and respectful patience. But even such things as we enjoy must come to an end. Another figure has arisen before you, one more familiar, and, therefore, less likely to command such respect. This is the man for the third time, not the 'Third Man' for the first time. Coal was the cry on the first occasion, and on the second not sealing wax nor kings, but cabbages. Tonight the cry is not a cry, but an echo, the echo of another's cry, 'Oil, oil for the glass furnaces of Albion.'

A Little Knowledge is Dangerous

"We have learned now a little about atomisation, and we must all be aware how dangerous that little is in the light of the much greater learning obviously possessed by the experts of the oil companies who serve us and this country so well. They know a great deal about the fuel oils distilled from the crude black liquid they tap from Mother Earth, their chemistry and physics, how to supply them within a works to the points of use and how best to atomise them at these points. We can even imagine that it would not be beyond their power to light on the magnificent Welsh hills so short a way from here, beacons which would illuminate our Western sky in such splendour as the setting sun himself could scarcely match.

"Magnificent as such a spectacle would be, it would not, of course, produce from the sands of Fontainebleau or Loch Aline, from the red lead of the Broken Hill mines, from the potash or soda of the I.C.I. colossus, that jewel we need, crystal glass, nor its seemingly far less romantic brother, the bottle. Seemingly less romantic indeed for what Merlin could make greater magic than the bottle-maker in his modern, fully-automatic plant. Here no human hand touches the raw materials flowing from silo to mixer, mixer to furnace, nor the glass falling or gathered into the hungry, whirling arms of the machine spewing its hot soldiers the stackers order in ranks still marching, shoulder to shoulder, glistening in well-annealed glory at the exits of the lehrs.

"We must look further afield to get our glass. We must call on the alchemist who presides over the mining of these riches of the earth, though tonight we have time only to pay him scant deference. We must call on the brick-maker, the iron founder and the still roller in whose ways there also lie a thousand and one romances we have not time to tell. Lastly, we must call on the furnace-maker, he whose living and dreaming thoughts are all of heat, flames and lightnings such as the Pit might see, sizzling currents such as delight Mephistopheles who loves him as a brother. As they from Babel he comes, uttering strange words, specific, coefficient, inflammability, luminosity, calorific, diffusivity, hinting at immortality with bold references to regeneration or recuperation, the while he confounds us by prophecy of savage fluxes attacking our refractoriness, and the dreaded spalling in which pieces fall from our very bones.

"But pity him, my brother, pity him for his labours are heavy upon him. Out of his knowledge of the technologies of fuel, glass, refractories, steel, iron and engineering he must bring forth answers to the glass-makers' prayers. His babblings but reflect the pangs of birth.

Costs

"Firstly he will inevitably be asked by the glass-maker, 'What shall it profit me if I use oil from Persia—or should it not now be Iran—instead of the black diamonds from my native soil?' And the proper answer should begin as was Dr. Joad's habit, 'It all depends—.' But general answers are quoted and one appeared in the paper given almost a year ago by one yclept Gill, an alchemist by training, a student of furnace-making by inclination, well known to all of you as a far from mean member of that company so much in the financial news of recent months, James Jobbing. His answer was itself a quotation from the Glass Review Fuel Efficiency Bulletin to the effect that when melting glass in tank furnaces and using black diamonds as fuel the overall

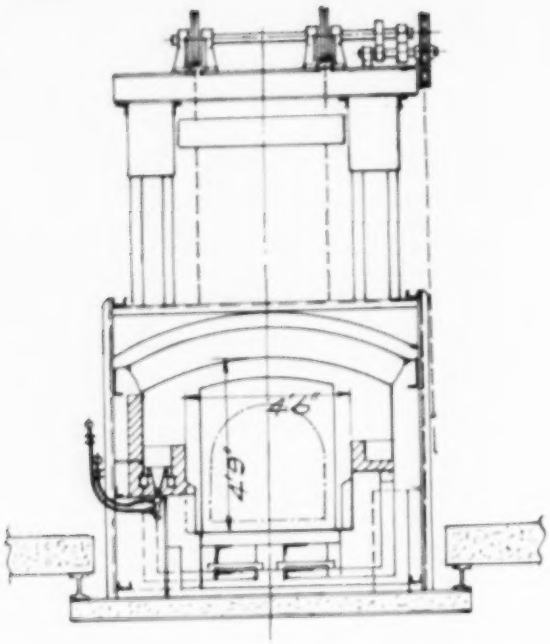

Fig. 2. Oil-fired semi - recuperative pot arch

cost for one ton of glass was £1 9s., the diamonds being relatively cheap at 42s. per ton. The cost when using the persistently odorous essence from Iran was £2 16s., the essence costing, curiously enough, more than the diamonds, £9 per ton. Alchemist Gill has revealed that his diamonds are now dearer at 49s. per ton, and the least amenable oil £7 2s. 6d. per ton, thus causing new costs per ton of glass, of £1 13s. 6d. and £2 4s. 4d. per ton respectively.

"Fortunate indeed is our friend, alchemist Gill, for black diamonds delivered in Stourbridge today, or more distant realms such as the Palatinate, may cost as much as 60s. per ton, and the Iranian essence of the least amenable type £8 per ton. With these costs the glass would cost £2 and £2 10s. per ton respectively.

"Alchemist Gill's quoted costs for labour and other additional costs have been included in all the foregoing comparisons, but it is extremely doubtful whether they would apply always, for circumstances alter cases as another example may emphasise. Mr. Tomes, once deputy engineer and manager of the Stourbridge Gas Department and now, for better or for worse, deputy engineer and manager of the Stourbridge branch of the West Midlands Gas Board, in a paper late in 1948 quoted the operational costs of a ten-pot furnace when various fuels were being used. That the costs were accurately assessed cannot be doubted, for the furnace belongs to one, Stuart and his sons, and let the Roundheads amongst you be assured that they do not, as some still do in the islands off Scotland's western coast, stick their stamps on upside down. Burning the best available local black diamonds the cost was 10s. 5d. per hour, burning the Iranian essence 12s. 6d. per hour. The authority of one of the Royalists is quoted that the consumption of Iranian essence is now 1 gal. per hr. less and the corresponding operative cost per hour therefore, reduced to 11s. 5d. at today's cost of the essence.

"There are hidden profits or losses not revealed by such comparisons and it can only be remarked that there are many who have converted their large pot furnaces or tank furnaces to oil firing and are well satisfied.

"Mr. Roddan has reminded you of

yet another evergreen question asked by the glass-maker of the furnace-maker: 'What manner of burner shall I use, that for which a small volume of air most puissant is needed or that absorbing a greater volume of air of inferior puissance?' Unlike our mutual friend, however, the furnace-maker, blinking wisely like the owl, says again, 'It all depends—.'

"In the mechanically magical plant of the bottle-maker there is little doubt that, to fire the tank furnaces, burners with air most puissant are best. Machines to compress the air are an essential part of the plant and the cost of producing it is not therefore, a first change on the melting process. The argument most vigorously propounded is that so little, approximately 5 per cent., cold air need be passed through these burners, the remainder can be full well pre-heated, making the greatest return of heat to the furnace and ensuring the lowest consumption of the Iranian essence. There is great substance in this argument although there may be those who have tried these burners on tank or pot furnace without the success anticipated. Probably some not too large alteration to the regenerators or recuperators would turn failure into success.

"The makers of glass by hand use, of course, naturally compressed air to blow their shapes, not as artlessly as the child with his bubbles, but with equally fascinating results. This naturally compressed air does not suffice for the burners of their pot furnaces. For these it has been commonly the practice to use the air of inferior puissance in the measure of one quarter of the total volume needed to burn the essence, and if this less puissant air be warmed to 250° C., the remaining three-quarters being strongly preheated in a refractory recuperator, the oil consumption will not be measurably different from that which may obtain were the burners absorbing air most puissant in use. But observe that apparatus, perhaps somewhat cumbersome, must be used to warm the atomising air.

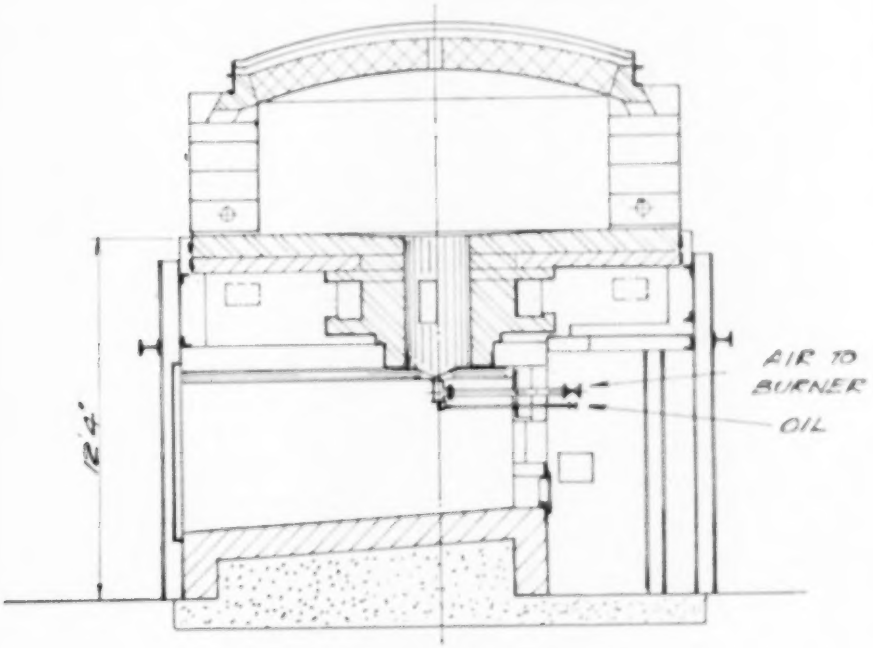

Fig. 3. Oil-fired 10 pot furnace

"Now he who beams the Royal name or he who secretly to the Red Rose owns allegiance, or he whose native land is by repute to the Englishman peopled by golden-haired women of surpassing beauty, each of these might ask the furnace-maker where he shall place the oil burner so that his large, round pot furnace may be heated with the greatest economy and to the least ruination of his tenderly nurtured vessels. The reply should be that he can place it above a central hole in the crown so that the atomised Iranian essence speeds vertically downwards to meet an upwardly rising current of heated air from the eye or he can place it with appropriate precautions so that the spray of essence ascends the eye in which it will be surrounded by the upwardly rising and twisting heated air ensuring its proper combustion.

Advantage of Heated Primary Air

"The former method rather reflects our friend's comments on compromise in applying oil burners, for it is more commonly used when converting producer gas-fired furnaces. There are advantages in the second method in that the primary air becomes heated on its way to the burner, the spray of essence is surrounded by hot air almost from its inception, the glass from broken pots drains the better away down the eye and is the more easily removed from the main pocket below. This last advantage weighs most heavily with those who labour to remove the glass. Lest it be feared that the performance of the burner may be a somewhat chancy matter when it is placed at the bottom of the eye, let it be noted that there are records of such burners being withdrawn for examination only once in a twelvemonth.

"He who makes the humble bottle or, to give it the more fashionable and pretentious name, the container, and to quote our beneficient assistant honorary secretary, 'our unwashed brethren from Smethwick,' are familiar with end- or cross-fired regenerative tank furnaces and end-fired recuperative ones. They are also familar with the compromise without end, as our Shell-Mexican friend has reminded us, to be made in designing the ports of the regenerative furnaces resulting neither in perfect combustion nor the best waste gas withdrawal. The end-fired recuperative furnace in its smaller sizes can hold its own with any type, but as the size increases—and here it is well to remember that all glass melting furnaces are feminine as those who know of Guy Simpson's favourite tank 'Lady Joan,' will appreciate as the size increases the 'oomph'—such a pronounced characteristic of the regenerative furnace decreases. But cross-fired recuperative furnaces can display as much attractive 'oomph' as the regenerative type without the encumbrance of the reversing necessary with the latter. The furnace-maker has a free hand to design ports which will give perfect combustion and waste gas draw-offs of the shape and size most appropriate. Moreover, the principle can be applied to both small and large tanks.

Hand Making

"The hand maker of glass must fire each of his vessels before it is taken for a ride by the variously and curiously-clad inquisitors to the last and extreme torture in the fiery furnace. The pot arches of the past compare to those of the present as the 'Ugly Sisters' to Cinderella. True, they devoured the relatively cheap black diamonds, but their thermal appetites were so large that they cost more to keep than their nymph-like sister does today, consuming more expensive food. Not wholly clay is her form, for air is entrapped therein and the bodies of countless diatoms make for her a cloak. So she is easily warmed by the expensive town gas. If one cares to feed her with Iranian essence from miniature burners matching her own delicacy she costs even less to keep.

"If the hand maker of glass should also wish to fire the rings from which is gathered the molten jewel, the stoppers for his vessels, the blocks to close the furnace arches, then he can do so in a single or double chamber kiln as like the nymph as a draiad.

"Before the epilogue let us look on a few still pictures, mostly reproductions of the black and white originals drawn by the skilful and cunning hand

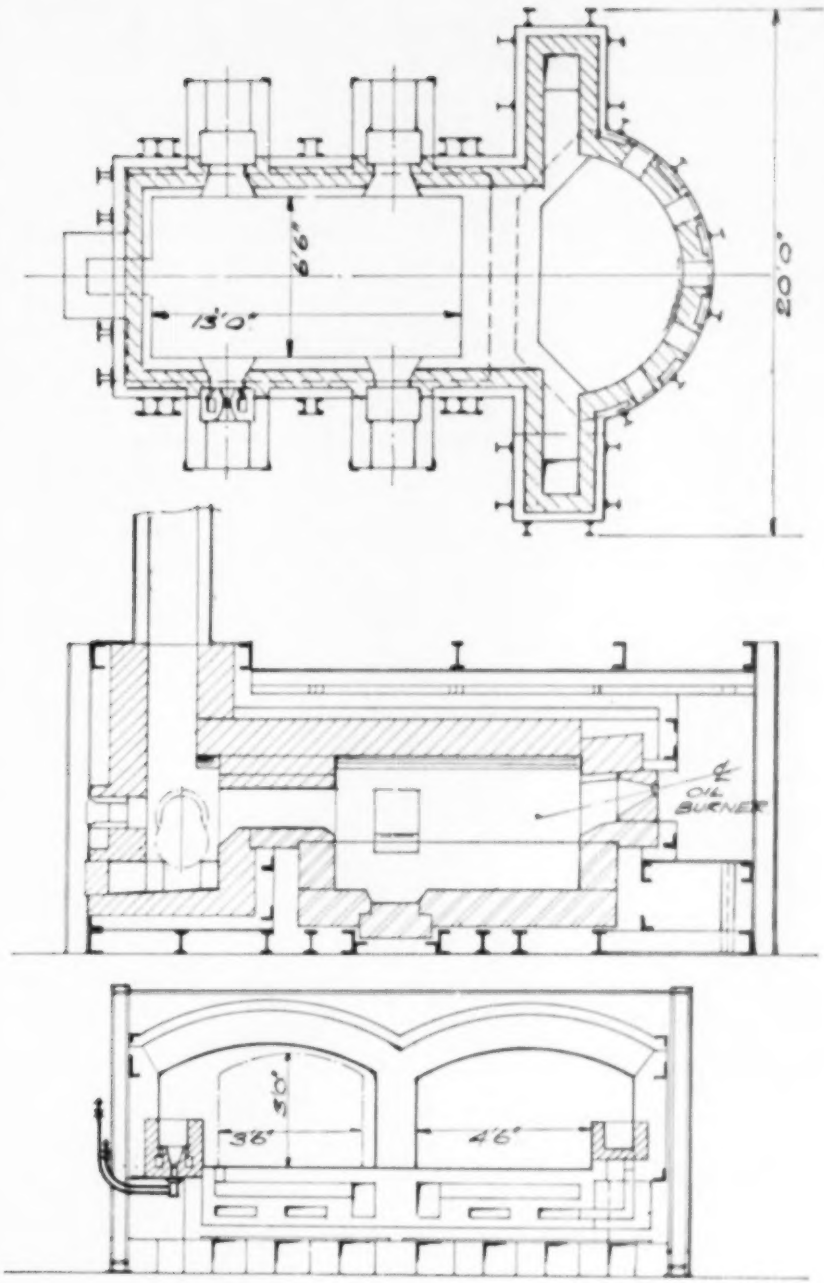

Fig. 4 (top). Oil/gas-fired glass melting tank
Fig. 5 (centre). Oil-fired miniature tank
Fig. 6 (bottom). Oil-fired twin chamber kiln

EDUCATIONAL

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

A SHORT course of lectures will be given from Monday, 25th September, to Friday, 29th September, inclusive, entitled "The Firing of Bricks." For further particulars apply to The Deputy Registrar, City and Guilds College, Exhibition Road, London, S.W.7.

of one of those diabolically befriended gentlemen previously referred to and an enthusiastic member of our committee.

"Here we have a furnace in which several of the large Stourbridge vessels can be placed, designed so that Iranian spray ascends to meet the upwardly rising and twisting hot air issuing from the ports but a short space above the burner. Observe the large pocket sealed by a door, proof against the heat, and of sufficient size to admit homo easer.

"A furnace similar to that described, but to hold four vessels, built in the works of the oldest glass-makers in England, is shown on the next two slides.

"Here is a furnace holding but one vessel, preferably open so that the riches of Mother Earth might be fused during the night and the shimmering liquid gems extracted during the day to the greatest profit of the maker.

"Here is a cross-fired recuperative tank furnace in which the baser soda-lime is melted for the pressing of tableware designed to remind us of the exquisite creations from Stourbridge an Englishman can no longer afford but the foreigner can. The flames from the opposing burners coalesce on the centre line and the products of combustion at extreme temperature pass through the shadow wall into the working end to the appropriately-placed off-takes whence they pass to the recuperator.

"Here is a miniature tank from which the maker might take the primary glass he desires in larger quantity each day the while he takes the secondary glass desired in smaller quantity from the skittle pots cunningly placed in the path of the hot gases, leaving the tank proper that he might more profit gain, though this is done under some protest by the furnace-maker at the glass-maker's request. Observe the steel bracing so arranged that when the glass-maker's morose doubts are dispelled and his coffers begin to overflow there might be added a recuperator that he might yet more profit gain.

"Here is an arch for the hand maker's vessels, the nymph. The miniature burners which can produce the Iranian spray at a rate as low as one-eighth or one-quarter of the maximum rate, fire upwards into a stream of air gradually increasing in temperature as the arching cycle proceeds. The products of combustion rising to the summit of the arch are drawn down to the hearth whence they pass through a recuperator to the stack.

"Here is the draiad and an identical twin in herself so that as one twin's passion cools, the passion of the other might be rising to a crescendo.

"The echo dies now as all echoes die, but the call will be raised again, 'Oil, oil for the glass furnaces of Albion,' and should you also wish to raise it, but doubts mingle with the urge within you, then now, now is the time to beseech the crier to dispel them, as I am sure right willingly he will do.

"You might also hear the echo again."

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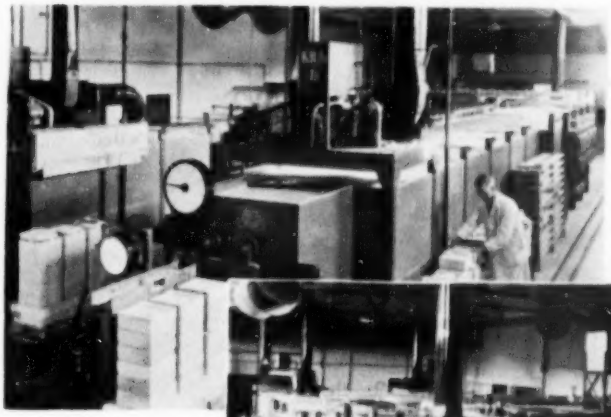

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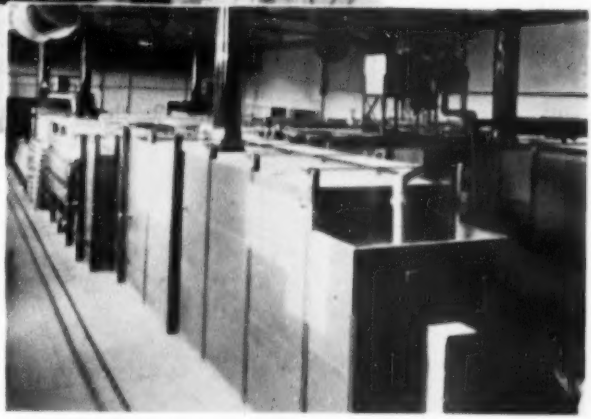

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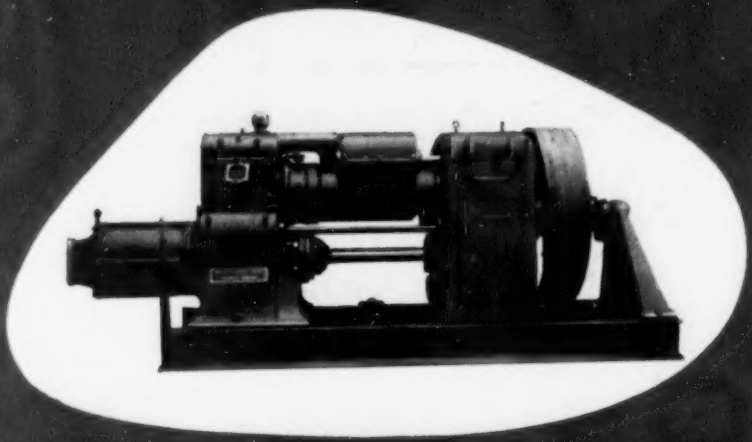

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